EARLY MAN IN NORTH-WEST INDIA

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Edited by

S.R.K. CHOPRA

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Contents

Palaeontological Evidence Bearing on the Problem of Human Origins in North-West India **S.R.K. Chopra** 1

Environment of Early man in North-West India: Palaeobotanical Evidence **Vishnu Mittre** 20

Stratigraphy and Palaeoecology of Quaternary Sediments of North-West Himalaya, India **V.J. Gupta, I.J. Suneja and S.R.K. Chopra** 66

The Early Man's Habitat in the Śivalik Hills: Some Statements on the Geomorphological Setting **A.B. Mukerji** 98

Pattern of Cultural Growth in Prehistoric North-West India **G.C. Mohapatra** 107

Index 135

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Palaeontological Evidence Bearing on the Problem of Human Origins in North-West India

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In an earlier communication the author has reviewed studies on primate palaeontology of the Śivaliks and highlighted the pioneering contributions of many palaeontologists and their enunciation of phyletic relationships for Śivalik primate fossils (Chopra, 1974). The bearing of such studies to the problem of primate origins and relationships provides a conceptual framework within which to understand evolution as a continuous biological process and to appreciate fully the impact and nature of our newer finds.

Ferishta (1360) makes the first recorded mention of fossils in India (Falconer, 1868). While the practice of fossil collection in India is ancient, the first serious attempt to their recovery and description was made by Webb, Buckland, Clift, Durand, Baker and Durand, Falconer, and Falconer and Cautley in the first half of the nineteenth century. Their work was supplemented by Lydekker in the later half of the nineteenth century, and by Pilgrim, Lewis, Sahni and Prasad in the present century. The fossil primates have generally formed a small part of the overall output of the vertebrate fossil finds in India. It was in the year 1836 that Falconer and Cautley first announced the discovery of a fossil primate from the Śivalik Hills of northern India (De Terra and Patterson, 1939). Among the lower primates limited descriptions are available of *Indraloris* (Lewis, 1933; Tattersall, 1968), *Papio* (v. Meyer, 1848; Lydekker, 1886; Verma, 1968), *Cercopithecus* (Pilgrim, 1910), *Semnopithecus* (Lydekker, 1884), and Macacus (Lydekker, 1378).

The fossil hominoids were first brought into focus by Lydekker

(1884) who described a partial palate assigned to *Palaeopithecus sivalensis* which was later renamed as *Sivapithecus* by Lewis (1937) and as *Dryopithecus* by Simons and Pilbeam (1965). Subsequent to Lydekker's contributions, Pilgrim (1910, 1915, 1927) described and proposed new species of fossil anthropoids, namely, *Sivapithecus indicus*, *S. middlemissi*, *S. orientalis*, *S. himalayensis*· *Dryopithecus punjabicus*, *D. chinjiensis*, *D. giganteus*; *Palaeosimia rugosidens*, *Palaeopithecus* (?) *sylvaticus*; *Hylopithecus hysudricus*. In the year 1923, Brown of the American Museum of Natural History recovered three dryopithecine fossils which were later described by Brown, Gregory and Hellman (1924) as belonging to three different species, viz., *Dryopithecus pilgrimi*, *D. cautleyi*, *D.* ? *frickae*. In 1926, Gregory and Hellman published an exhaustive monograph detailing a comparative study of the dryopithecine dentition. Following these earlier contributions, the Yale-North India expedition of 1931-33 and Yale-Cambridge expedition of 1935 added further to the collections of fossil primates from the Śivaliks. Lewis (1934) and Gregory, Hellman and Lewis (1938) communicated the scientific results of these expeditions.

Lewis (1934) also proposed a number of new taxa, namely, *Sugrivapithecus salmontanus*; *Dryopithecus cautleyi*, *D. sivalensis*; *Bramapithecus thorpei*; *Adaetontherium incognitum*; on the basis of his studies on further fossil finds consisting of fragments of mandibles, maxillae, and teeth. The most thoroughly monographed description of the Śivalik collections in the American Museum of Natural History was published by Colbert (1935) which also included a systematic account of the various described genera and species of the primates. In a subsequent publication, Lewis (1937) proposed a reduction, by synonymy, of over twenty species and half as many genera of the Śivalik fossil anthropoids thus far reported, to only four genera with ten species, namely, *Bramapithecus* (*B. punjabicus*, *B. sivalensis*, *B. thorpei*); *Ramapithecus* (*R. brevirostris*); *Sivapithecus* (*S. darwini*, *S. giganteus*, *S. indicus*, *S. sivalensis*), and *Sugrivapithecus* (*S. salmontanus*; *S. gregoryi*). Wadia and Aiyengar (1938) provided a list, with brief notes, of fossil primate collections of the Geological Survey of India which were earlier recovered from the Tertiary deposits of the Indian sub-continent. According to them, about eighty-two distinct primates arranged into eleven genera and about twenty-one species had been recovered. Gregory, Hellman and Lewis (1938) described the fossil primate collections of the Yale-Cambridge India

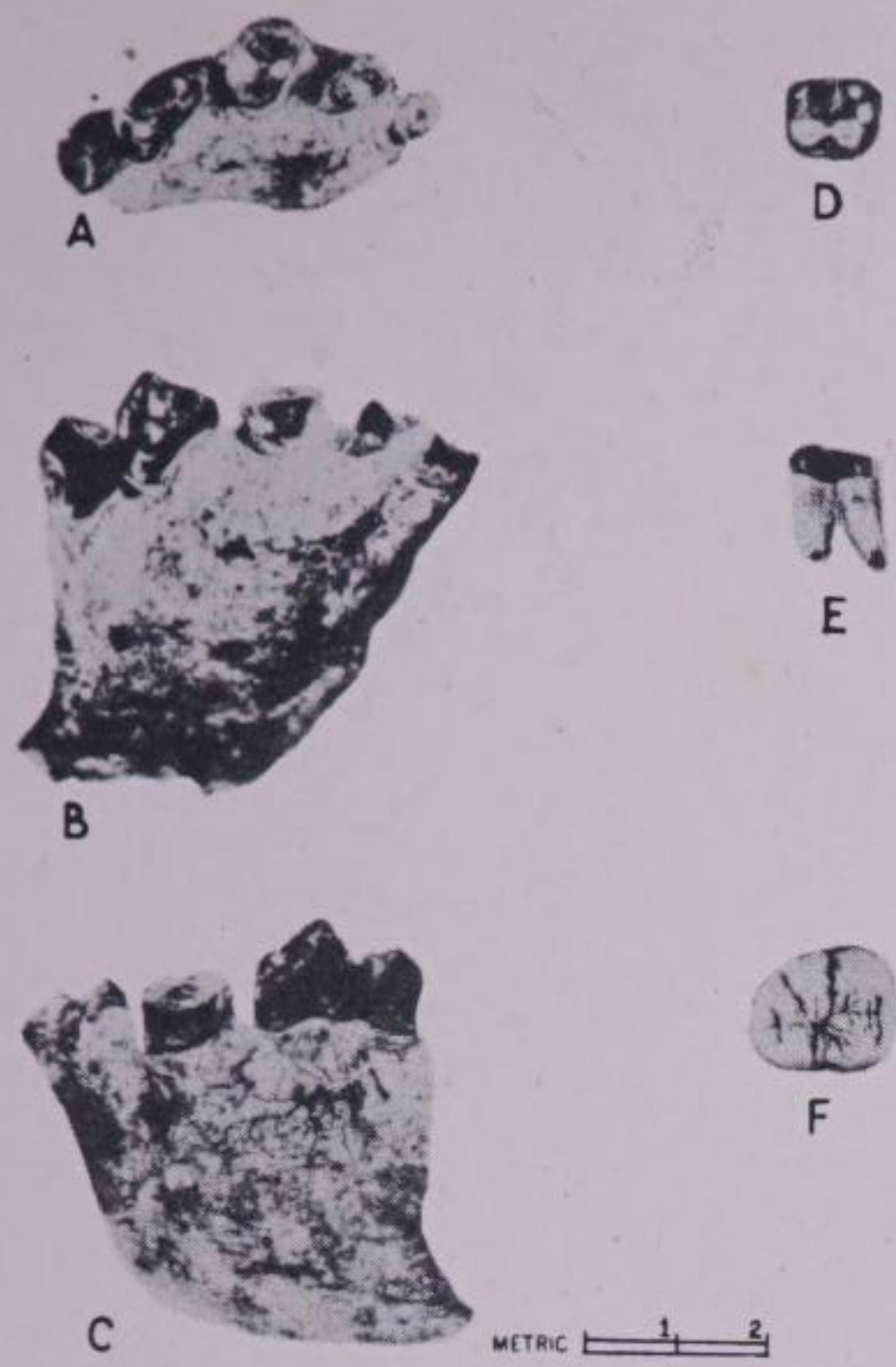

Fig. 1 Dryopithecines: *A* occlusal view, *B* internal view, and *C* external view of the left mandibular fragment (PUA 1047-69), *D* occlusal view and *E* external view of the left lower M_1 (PUA 760-69), *F* occlusal view of left lower M_3 crown (PUA 1052-69)

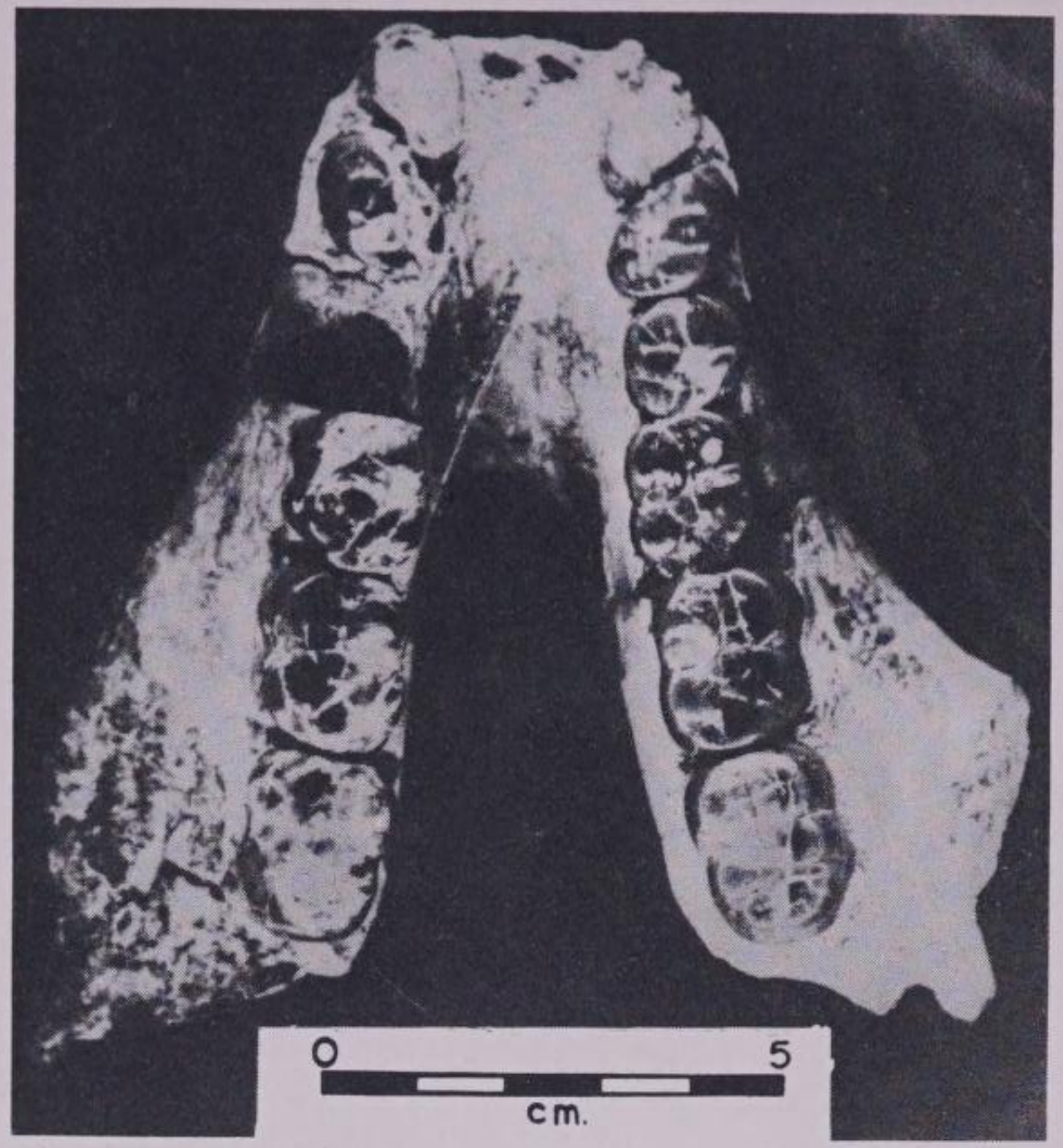

Fig. 2 *Gigantopithecus bilaspurensis;* mandible

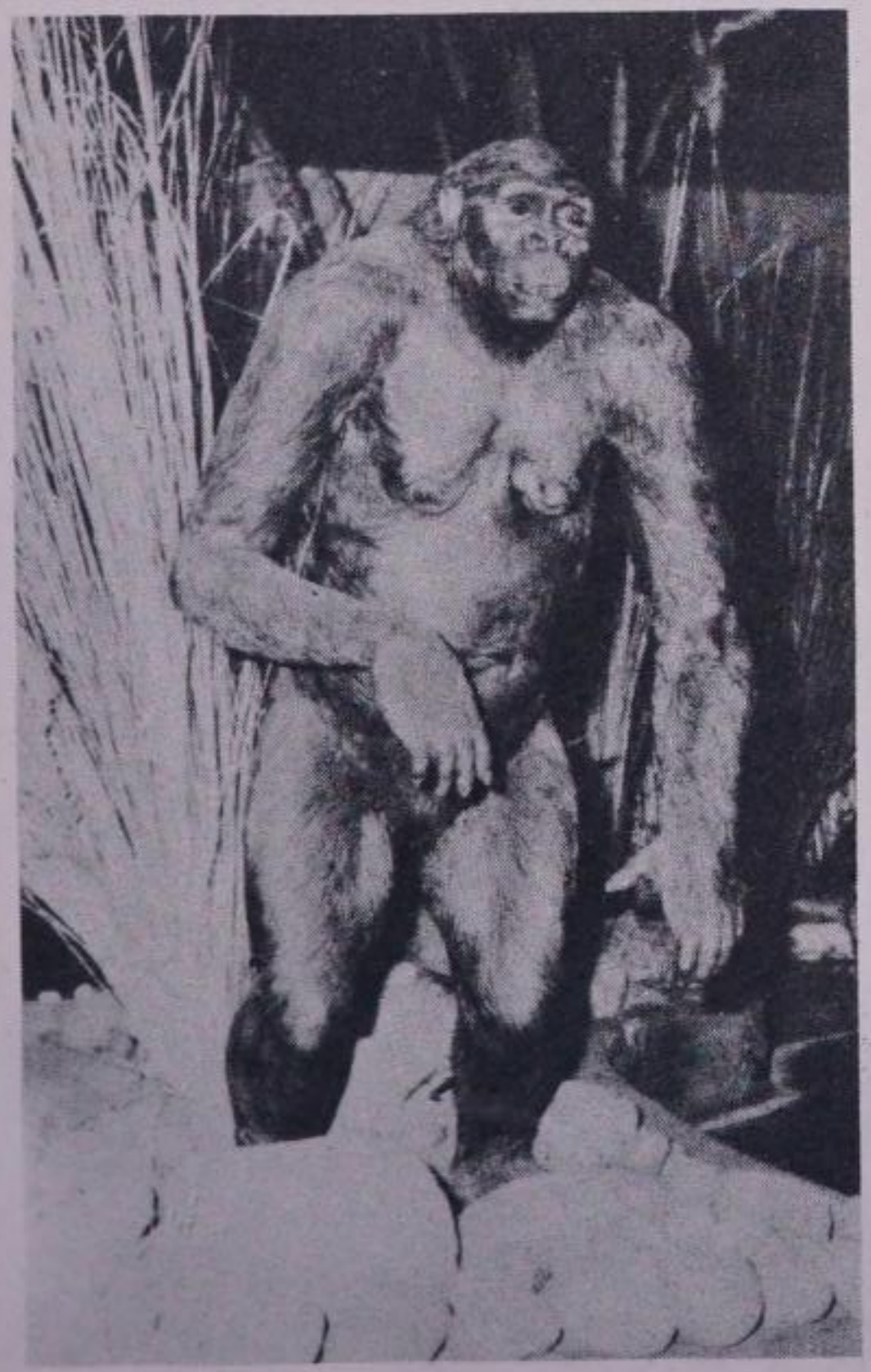

Fig. 3 *Gigantopithecus bilaspurensis;* life-size restoration

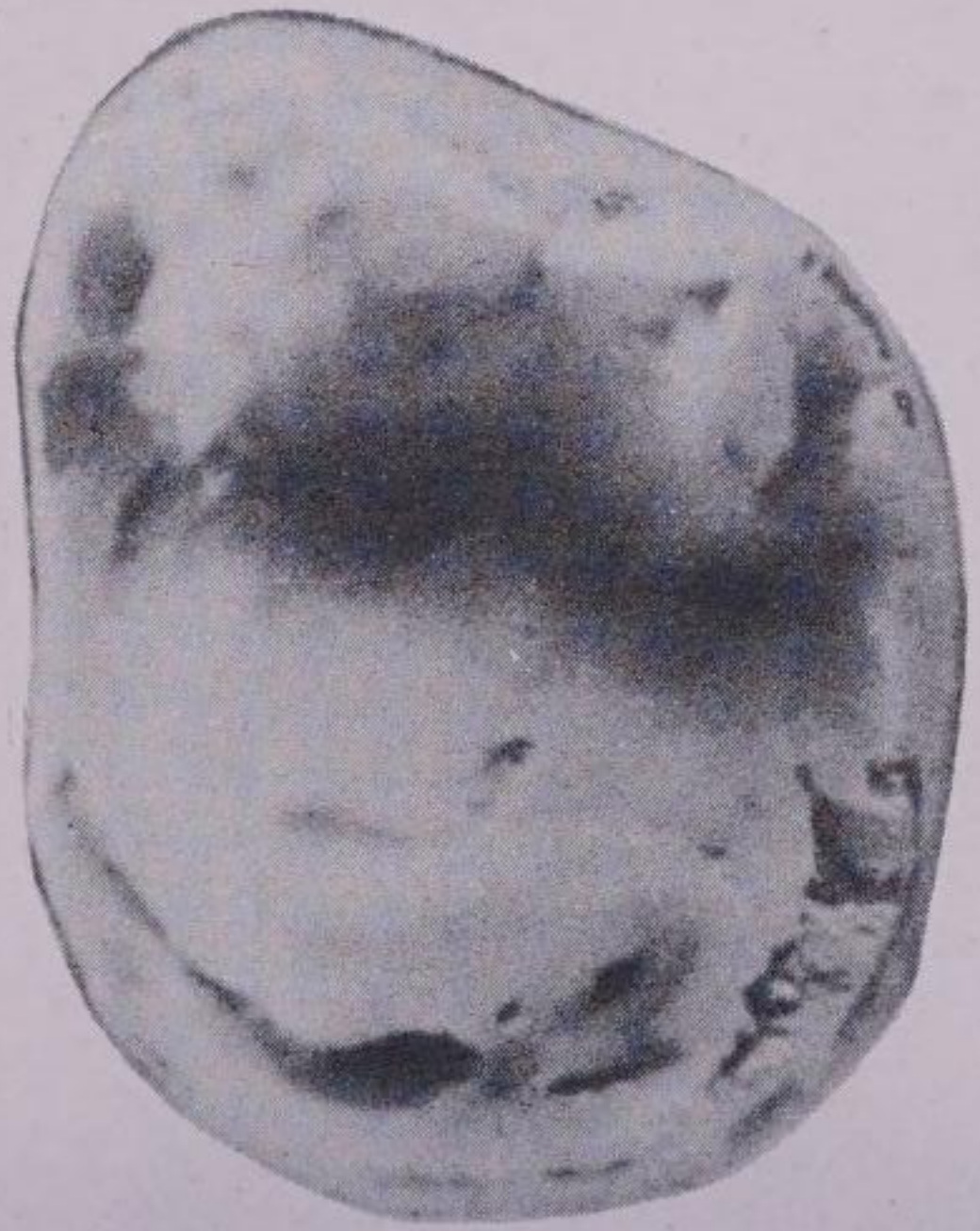

Fig. 4 *Pliopithecus krishnaii;* left upper M_3

Fig. 5 *Pliopithecus;* life-size restoration

Fig. 6 *Ramapithecus;* life-size restoration

expedition and also a small part of primate teeth collection of the Geological Survey of India including an isolated lower third molar loaned by the Prince of Wales College Museum, Jammu. On the basis of their extensive studies on the structural variations of the shape and size of the mandible and particularly of the dentition, it was suggested that the Indian dryopithecines were more advanced than their European counterparts (Gregory, Hellman and Lewis, 1938). Recently Prasad (1962, 1964, 1968, 1969a, b) recovered and described a number of specimens of fossil anthropoids from the Nagri beds of Haritalyangar, namely *Sivapithecus* (*S. aiyangari, S. indicus* and *S. sivalensis*); *Sugrivapithecus* (*S. gregoryi* and *S. salmontanus*); *Dryopithecus punjabicus.*

Simons and Pilbeam (1965) included all the known fossil hominoids from the Śivaliks into two genera, namely, *Dryopithecus* (Family Pongidae) and *Ramapithecus* (Family Hominidae). The Indian material included in the genus *Dryopithecus* was assigned to three species, namely *D. laietanus, D. indicus,* and *D. sivalensis.* These include the following forms:

(a) *D. laietanus:*
Ramapithecus cf. *brevirostris* (G.S.I. – D618*);

(b) *D. indicus*:
Sivapithecus indicus, S. himalayensis, S. orientalis, S. orientalis, S. middlemessi, S. giganteus, S. aiyengari; Dryopithecus ? *frickae, D.* sp. Pilgrim, *D. giganteus* and *Indopithecus giganteus*;

(c) *D. sivalensis*:
Dryopithecus chinjiensis, D. pilgrimi, D. cauteleyi; *Palaeopithecus sivalensis, P* ? *sylvaticus*; *Palaeosimia rugosidens*; *Ramapithecus hariensis*; *Sugrivapithecus gregoryi* and *S. salmontanus.*

The other Śivalik hominoid material, namely, *Dryopithecus punjabicus*, *Ramapithecus brevirostris* (Y.P.M. No. 13799), *Bramapithecus thorpei*, and *B* ? *sivalensis*, is included in the genus *Ramapithecus* represented by a single species, i.e., *Ramapithecus punjabicus*. This taxonomic revision proposed by Simons and Pilbeam (1965) seeks to limit the concept of generic diversity among the Mio-Pliocene dryopithecine fauna on the basis of morphological, temporal and zoogeographic correlations. Whilst the proposed classification is

*This original specimen is not traceable and is represented by a cast Y.P.M. No.13870.

found instructive in so far as it points to a considerable amount of synonymy among the Śivalik primates, the conclusions "cannot be regarded as final, for recovery of more material may well alter the taxonomy" (Simons and Pilbeam, 1965). Prasad, (1969a) suggested a generic distinction for *Sivapithecus* particularly on the basis of his detailed morphological, biometric, and X-ray studies of the *Sivapithecus* material and included *Ramapithecus* cf. *brevirostris* (D-618) under what he termed as "*Sivapithecus chinjiensis* (Pilgrim), a pygmy-sized species of the *Sivapithecus* from the Siwaliks hitherto unrecognised". This mandible, D-618 (*Ramapithecus* cf. *brevirostris*), was earlier assigned to *Dryopithecus laietanus* by Simons and Pilbeam (1965). Prasad (1969a) does not consider *Ramapithecus* to be monotypic as Simons and Pilbeam (1965) had suggested but recognises two species, i.e., *R. punjabicus* (Pilgrim) and *R. brevirostris*. According to him *R. punjabicus* was "a short faced form, (and) smaller in size to *R. brevirostris*".

In 1968, a new species of *Sivapithecus-S. lewisi* based on a study of a broken right ramus from the Nagri beds in Kangra was described by Pandey and Sastri. Gupta (1969) reported on additional dryopithecine material which he assigned to *Sivapithecus indicus*. The material consisted of a fragment of a left mandibular ramus with M_1 and P_4, and an isolated premolar. These fossils were recovered from the same site in Kangra as the one from where earlier *S. lewisi* was reported by Pandey and Sastri. Recently Chopra and Kaul (1975) have described new fossil *Dryopithecus* material of the Indian Śivaliks consisting of a fragment of left mandible, an isolated left first molar and a crown of a lower last molar from the Nagri beds at Haritalyangar in Himachal Pradesh. A systematic account of these is presented below.

Genus *Dryopithecus* Lartet 1856; *Dryopithecus sivalensis* Lydekker 1879.

The material comprising a mandibular fragment (PUA 1047-69) and an isolated molar (PUA 760-69) have been collected from the Nagri beds of Haritalyangar in the district of Bilaspur, Himachal Pradesh. The geological formations in this area extend from the Lower to Upper Śivaliks and the bulk of fossils have come from the Nagri (Sarmatian) and Dhokpathan (Pontian) stages. The present specimens were found in the argillaceous unit of the Hari and Dangar scarps (Nagri stage). The Nagri beds in this area comprise thick bands of medium-to-coarse-grained sandstones, moderately compact and varying from greyish to greenish in shade. These massive sandstone bands

alternate with richly fossiliferous, light to dark pinkish, highly jointed and friable argillaceous horizons. The beds have gentle dips (generally between 8° and 20°) in the north-east direction.

Mandibular fragment (PUA 1047-9)

The mandibular fragment consists of two premolars, and partly broken canine and incisors. The state of preservation of both the body of the mandible and two premolars is excellent. The mandible is broken off immediately mesial to I_1 and distal to P_4, thereby exposing their roots almost to the base (fig. 1).

In its height the symphysis of the present specimen approximates the figures recorded for both *D. nyanzae* and *D. fontani* (Chopra and Kaul, 1975) but is not as massive. The slenderness of this specimen is also indicated by its symphysial cross-section when compared with the African and European species. The vertical axis of the symphysis does not slope as distinctly as in *D. fontani* and *D. nyanzae*. There are two mental foramena, one below P_3 is distinct and the other below P_4 is smaller and less marked. They are placed about 3 mm apart from each other. The depth of the mental foramen below P_3 is 20.6 mm and P_4 19.0 mm.

The incisors and the canine being partly broken, no reliable measurements can be taken. In their length and breadth dimensions P_3 and P_4 approximate the figures recorded for two other specimens of *D. sivalensis*, namely, GSI 18069 and AMNH 19412. Among the living anthropoid apes, these dimensions approach the figures for *Pan troglodytes* and also fall within the ranges for female *Pongo*.

P_3 is rectangular and has a sloping outer surface for the maxillary canine. It shows the beginnings of the metaconid. P_4 is slightly laterally compressed and indicates the presence of the hypoconid. A slight diastema is present between the canine and P_3. The premolars have shown well-separated anterior and posterior roots on an X-ray plate.

Isolated molar (PUA 760-69)

It is a moderately worn tooth and bears two well-preserved roots placed antero-posteriorly.

The specimen, a left lower molar, is of smaller size, in its both length and breadth dimensions, in comparison to other known

specimens of *D. sivalensis, D. fontani, D. indicus* and living anthropoid apes (Chopra and Kaul 1975). The buccal cusps of the present specimen are somewhat rounded with primary ridges and wrinkles present on the occlusal surface. The lingual cusps are placed at a higher level than the buccal cusps which show marked perforations on their enamel. The hypoconulid is small and centrally placed and is less visible from the buccal side. The external cingulum is vestigial or absent.

Genus *Dryopithecus* Lartet (1856), *Dryopithecus* sp.
Isolated Molar (PUA 1052-69)

This specimen, which comes from the same area as the above two specimens, is merely the crown of a lower third molar. While in its overall dimensions the present specimen is somewhat intermediate between *D. indicus* and *Ramapithecus punjabicus* (Chopra and Kaul, 1975), in its length and breadth dimensions it approximates closely to the figures for male orangs and also falls within the range for female orangs and female gorillas.

The molar crown is rectangular and shows slight tapering on the buccal side at the level of the hypoconulid. The cusps descend steeply to the base of the crown on the lingual side and more gently on the buccal side. The metaconid is largest (fig. 1F) and highest of all the cusps present in the specimen. The two buccal cusps, namely, protoconid and hypoconid, are almost of equal size and height. The entoconid is a little smaller while the hypoconulid is the smallest of all the cusps. There is no indication of a cingular connection. The furrows between buccal cusps are deeper and run down to the base of the crown. In these and other morphological features, including the nature of its enamel foldings, it is similar to GSI D-175 assigned to *D. indicus*.

Genus *Gigantopithecus* von Koeningswald 1935; *Gigantopithecus bilaspurensis* Chopra 1968.

In April 1968, a mandible of a new species of *Gigantopithecus* was recovered from the Dhokpathan horizon of the Śivalik Group in the east of Haritalyangar village in Himachal Pradesh. Chopra (1968a, b) first announced and identified this important find as constituting a new species of *Gigantopithecus*, namely, *G. bilaspurensis*. Subsequently, Simons and Chopra (1969a, b) and Chopra (1974) published more scientific details on the new find. This material has also received

attention from Jolly (1970), Simons and Ettel (1970), Pilbeam (1970), Groves (1970), Frayer (1973), Robinson and Steudel (1973), and Corruccini (1975). The fossil of *G. bilaspurensis* was found in three associated parts and is the most complete lower jaw of any primate found in the fossiliferous beds of the Indian Śivaliks. It preserves horizontal rami complete to the base of the ascending ramus on both sides and is intact at the level of the symphysis. It has nearly a complete array of teeth except the front two incisors and a left premolar (fig. 2). The incisors must have been comparatively small, as is indicated by a greatly reduced anterior space in the jaw. The jaw is slightly smaller in absolute size than the smallest known *Gigantopithecus* found in the Pleistocene deposits of China. Judging from the dental formation its large molars cover almost the same jaw length as in apes but the horizontal rami of the mandibles in *Gigantopithecus* are more robust and relatively deeper than in any of the living apes. The dental arcades show marked posterior divergence, a primitive character which it shares with the Miocene apes as also with the Fayum Oligocene *Aegyptopithecus*.

The incisors of *G. bilaspurensis* are missing but the greatly reduced anterior region in the mandible shows crowding of the front teeth unlike the condition found in modern apes where the incisors are relatively large and occupy greater anterior space. The incisors in *Gigantopithecus* formed a compressed anteriorly facing arc as is evidenced from the wear facet on the canine formed by interstitial attrition and the breadth across the four incisor teeth (Woo, 1962; Simons and Chopra, 1969b).

The canines, though partly broken, do give evidence of wear in a posteriorly sloping plane. Relative to the size of premolars and molars the canine teeth are reduced and should have been barely overlapping when in occlusion with the upper canines.

The premolars are relatively large in size. The metaconid is well developed and gives the premolar a bicuspid look. The crenulations or the ridges on the metaconid are barely noticeable and there is no wear facet on the anterolateral boss of P_3 as is usually found in anthropoid apes. The trigonid in P_4 is extremely low but expanded and the talonid is greatly reduced.

There is a progressive increase in the overall size of molars from M_1 to M_3. The occlusal surfaces are worn flat and the cusps lack prominent ridges or crenulations. The molars in *G. bilaspurensis* are brachyodont unlike those of *G. blacki* which show incipient hypsodonty.

Measurements and indices taken on the teeth of *G. bilaspurensis* have been compared, in figs. 1 and 2, with the data on extant and fossil apes (Ashton and Zuckerman 1950a, b). From an assessment of the dental characters, based on comparative odontometric studies, it would appear that in overall dimensions the canine in *G. bilaspurensis* is comparatively reduced in size, P_3 is slightly smaller in size than P_4 and finally there is a progressive increase in size from M_1 to M_3.

From descriptions of both the species of *Gigantopithecus* it becomes evident that this genus shows greater affinity with the pongids than with the hominids. It is, however, clear that the fossil jaw of *G. bilaspurensis* shows some hominid characteristics in its anterior region, as is evidenced by a marked reduction of the front teeth, relatively small canine and tooth wear. Such hominid features are related to a change in the masticatory function and these could at best be considered as parallelisms with the important implication that hominid-like tendencies, as are seen in the fossil jaw, were already underway some 5 to 10 million years ago in the Pliocene period.

If the dimensions of the jaw are any indication of the body size, the giant ape might have weighed and attained a size not much larger than the present-day gorilla (fig. 3). The gorilla weighs about 400 pounds and, when standing bipedally, is approximately 6 feet tall. In various ways this find bears resemblance with other Śivalik fossil apes, particularly the dryopithecines. Being considerably older in age than the Chinese *Gigantopithecus* it will shed new light on the initial stages of differentiation of hominids and man-like primates.

Genus *Pliopithecus* Gervais 1845; *Pliopithecus krishnaii* sp. nov.

Follow-up researches in the Śivaliks by the author and his associates have led to the discovery of a site about 500 m west of the famous Hari Temple in Haritalyangar in Himachal Pradesh which yielded a rich collection of primitive monkeys (*Indraloris*). Among the collections from this site is found an easily identifiable third upper left molar completely detached from the rest of the dention of a gibbon-like fossil primate. It was recovered from the Nagri beds of the Śivaliks comparable to the Middle Miocene Formations and is the first of its kind ever reported from these hills.

It is characterised by three well-developed cusps – paracone, metacone and protocone with an incipient fourth cusp, the hypocone. Of these the paracone and the metacone constitute the two lateral

cusps and protocone, the medial cusp. The protocone stands on the lingual marginal ridge which becomes connected across the central valley to the metacone by the development of a christa obliqua (fig. 4). The lingual cingulum begins from the medial aspect half way from the protocone. It surrounds the base of the protocone and ascends distally to form the fourth cusp – the hypocone. The lingual cingulum in the fossil tooth is only moderately developed. The degree of expression of the cingulum and its gradual reduction has been considered as a progressive feature of the hominoid including hylobatid evolution. There is a very clear contact facet. The slight tooth wear is suggestive of the fact that it belonged to a young animal which had probably just finished erupting its teeth.

The tooth measures 5.7 mm in its anteroposterior diameter and 7.05 mm in bucco-lingual diameter. In its a.p. diameter the molar falls well within the range of fossil and living gibbons as is evident from table 1.

Table 1: Length and breadth dimensions of new molar (PUA 950-69) compared with other fossil and living hylobatids

	a.p.	m.d.	Index	
Pliopithecus krishnaii (PUA 950-69)	5.70	7.05	123.7	present study
P. cf. *antiqus*	5.5-6.9	—	—	Frisch, 1973
P. vindobonensis II	6.2	—	—	Frisch, 1973
P. vindobonensis III	6.9	—	—	Frisch, 1973
Limnopithecus legelet	5.1	—	—	Frisch, 1973
L. macinesi	5.9-6.6	—	—	Frisch, 1973

The earliest hylobatids are known from the Miocene deposits of East Africa and Europe as *Limnopithecus* and *Pliopithecus* respectively. These are closely related forms which are now grouped under a single genus *Pliopithecus*. The African *Limnopithecus* lived in ecological conditions corresponding to areas of primary rain forests whereas the European *Pliopithecus* has been known to represent a type of adaptation to a wide range of habitats including open woodlands and dry forests. The Indian form was, however, adapted to sub-tropical rain forest conditions which characterised the upper Middle Miocene times in the Śivaliks (fig. 5). During the successive periods of time in the Pliocene and the Pleistocene when openlands

appeared and the areas became less forested, these forms must have migrated to South-East Asia and South China from where some post-Miocene hylobatid dental material has been reported from the Pleistocene deposits.

Genus: *Ramapithecus* Lewis 1934

Among the fossil hominoids of the Śivaliks *Ramapithecus* alone has been considered as a possible Miocene hominid. Lewis (1934) reported principally on this new genus and proposed two species of this taxon. The name *Ramapithecus brevirostris* was assigned to the type consisting of a "right maxilla and premaxilla with M^2, M^1, P^4, P^3, the alveolus of the canine, the root of I^2 and the alveolus of I^1 (Y.P.M. No. 13799)", found one quarter of a mile east of Chakrana which is situated about four miles east of Haritalyangar village in Himachal Pradesh. The other species *Ramapithecus hariensis* was assigned to the type consisting of a fragment of the right maxilla containing the first and second molars (Y.P.M. No. 13807). This was found one quarter of a mile east of Haritalyangar village in Himachal Pradesh. The geologic and taxonomic position of *Ramapithecus* has been a subject of much discussion. Lewis (1934) first assigned *Ramapithecus brevirostris* (Y.P.M.P. No. 13799) to "Pliocene-Either Latest Middle Siwalik (Dhokpathan) or basal Upper Siwalik (Tatrot)" horizon and *Ramapithecus hariensis* (Y.P.M. No. 13807) to "the Lower Middle Siwalik-Nagri" horizon. In a later publication, however, Lewis (1937) fixed the provenance of specimen Y.P.M.P. No. 13799 in the Nagri formations representing "the Lower Middle Siwaliks (Pliocene)" at Haritalyangar. Hooijer and Colbert (1951) referred to *Ramapithecus* as occurring in the Tatrot horizon. However, Prasad (1964) and Simons and Pilbeam (1965) assigned *Ramapithecus* to Nagri beds on the basis of detailed studies including analysis of the matrix.

Simons and Pilbeam (1965) in their preliminary revision of the dryopithecines, included *Ramapithecus brevirostris* (Y.P.M. No. 13799) in the family Hominidae and *Ramapithecus hariensis* (Y.P.M. No. 13807*) in the family Pongidae. On the basis of a study of various dimensions and details particularly of dental morphology, Lewis

*Y.P.M. No. 13807 is now numbered as M.C.Z. 8386 and is in the collections of the Museum of Comparative Zoology, Harvard. This is synonymised with *Sivapithecus sivalensis* (Simons and Pilbeam, 1965).

(1934, 1937) suggested that *Ramapithecus* might well belong to the family Hominidae, a view which has found support in many recent publications (Simons and Pilbeam, 1965; Prasad, 1968). Simons and Pilbeam (1965) have even speculated that *Ramapithecus* could have been "ad hoc tool users". Tattersal (1969a) suggested that the Nagri environment in which *Ramapithecus* lived consisted of tropical forests which were interspersed with broad rivers and tree savanna. From the environmental picture as has been reconstructed by Tattersal (1969a) and Prasad (1971) one would expect *Ramapithecus* to possess bipedal locomotion usually typical for such forms in an open country (fig. 6). However, no postcranial skeletal finds of *Ramapithecus* have so far been recovered which may be indicative of its locomotor adaptations. Pilbeam (1968) suggested that *Ramapithecus* should be classified as a hominid even if it is shown not to possess a habitual bipedal locomotion.

In 1969, Pilbeam described a damaged mandibular fragment (M 15423) in the collections of the British Museum of Natural History which he claimed was very similar to *Ramapithecus* and had not been hitherto identified. This contention was effectively countered by Leakey (1970) who held that originally Simons and Pilbeam (1965) had assigned this specimen to *D. laietanus* which came from the Upper Chinjis at Domeli. In a recent paper Conroy and Pilbeam (1975) assigned specimens G.S.I.-D. 199 and BMNH-15423 to *Ramapithecus* and argued for their placement in the family Hominidae. Earlier, Jolly (1970) had identified an adaptive "T" complex in the dental characteristics including cheek teeth crowding, extensive interstitial wear, a steep molar gradient, broad molar with thick enamel and a thick mandibular body, as important hominid adaptations. These criteria were used in the interpretation of the ecology of both *Ramapithecus* and *Gigantopithecus*. However, Wolpoff (1971) and Greenfield (1974) have critically examined the validity of such criteria in determining the hominid status of fossils and consider the presence or absence of these features as "neither unique to hominids nor taxonomically significant" but largely dependent upon "age and/or sex of the individual, regardless of familial association". It would thus be clear that the hominid characteristics of the facial and dental morphology of the *Ramapithecus* notwithstanding, its taxonomic status may at best be hypothesised and not finalised on the basis of the existing evidence.

A review of the Śivalik hominoid material, including dryopithe-

cines, *Gigantopithecus* (*G. bilaspurensis*), *Pliopithecus* (*P. krishnaii*), *Ramapithecus*, its distribution and geological locations in the Indian sub-continent shows that bulk of the material comes from the Mio-Pliocene beds in the Potwar region of Pakistan, around Ramanagar in Jammu and Kashmir, and in Haritalyangar in Himachal Pradesh. Tattersal (1969a) wrote on the forest ecology of *Ramapithecus* on the basis of faunal evidence derived from the Nagri formation of the Śivaliks in northern India. In a subsequent publication he quotes extensively the observations of Krynine (1937) relating to the palaeoecology of the deposits during Chinji, Nagri, and Dhok Pathan times based on lithological analysis of the Śivalik Group (Tattersal, 1969b). Summarising Krynine's (1937) conclusions, Tattersal (1969b) states: "The Chinji deposits are primarily composed of fine-grained red clastics, while the rest of the section consists of medium-grained clastics of the channel type. Intra-formational conglomerates indicate river-channel boundaries and there is evidence of post-depositional weathering penecontemporaneous with deposition. . .these sediments indicate a humid tropical climate with heavy seasonal rainfall resulting in short, destructive floods; and shifting, wide rivers flowing through a heavily-forested, flat country with numerous water bodies and a relatively small number of open clearings. During Nagri time the medium-grained predominated over the fine-grained clastics. Rainfall was probably more seasonal than during Chinji time, but a forested environment prevailed though perhaps more broken than during the Chinji. Only with the Dhokpathan is the lithological and faunal evidence indicative of the formation of the open prairie and, at the top of this zone, an arid environment."

The Chinji-Nagri and Dhokpathan fauna, comprising rodents, carnivores, perissodactyles, artiodactyles, and proboscidians besides primates, is indicative of a mixed forest environment with open grass lands, scattered trees interspersed with meandering rivers and streams. Our own observations based on fossil floral remains comprising leaf impressions of dicotyledonous plants and fossilised woody tissues from the Nahans and Nagris are suggestive of a thick floral cover during these times. The leaf impressions are with entire margins and with drip points indicating general tropical climatic conditions with adequate rainfall.

The Pleistocene of the Indian sub-continent, as also elsewhere, marks the close of the Tertiary Period and the beginning of the Quaternary. In the northern world including Europe and North

America it generated widespread cold conditions leading to the ice or the glacial age. In India, however, the Pleistocene has had, "a fuller and more varied development than all the preceding systems save the Archaean; it covers 250,000 sq. miles of North India under river deposits; there are long stretches of contemporaneous ice-deposits in the Middle and Inner Himalayas, and desert, lateritic, littoral, lacustrine and subaerial accumulations in other parts of the country. An occurrence of sub-Recent ossiferous gravels over 3000 feet deep in the upper Sutlej basin gives us a clue to the varied geological, biological and meteorological conditions prevailing in India during the period. Extensive linear faulting along the west coast and tectonic disturbance of gravel beds, Karewas and Upper Siwalik strata are of further interest, showing that this last and sub-Recent epoch of earth history was not free from orogenic movements of a significant nature. . . .In India it must be understood, we cannot look for the actual existence of ice sheets during the Pleistocene glacial epoch, because a refrigeration which can produce glacial conditions in Northern Europe and America would not, the present zonal distribution of the climate being assumed, be enough to depress the temperature of India beyond that of the present temperate zones. Hence we should not look for its evidence in moraine debris and rock-striations (except in the Himalayas), but in the indirect organic evidence of the influence of such a lowering of the temperature and the consequent increase of humidity on the plants and animals then living in India. Humidity or dampness of climate has been found to possess as much influence on the distribution of species in India as temperature. From this point of view sufficient evidence exists of the glacial cold of the northern regions being felt in the plains of India, though to a much less extent, in times succeeding the Śiwalik epoch after the Himalayan range had attained its full elevation" (Wadia, 1966). However, there has been evidence of hill ranges in Rajasthan and elsewhere where the temperate fauna and flora are found closely allied to those of the Himalaya. These are some of the peculiarites of the faunal and floral assemblages which have been explained as being due to depression in temperature.

It is now agreed that the Pleistocene in India was ushered in by an orogenic uplift culminating in general cooling down of temperature and distinct changes in fauna and climate. The Pleistocene and Recent deposits of the northwest India include the terraces of the rivers Beas, Sutlej, Tawi, Ravi, Chenab, etc., the lacustrine deposits of Kashmir

(Upper Karewas) and similar deposits in Kumaun (Pithoragarh) and Nepal (Tanr); the loess deposits of the Salt Range, Potwar and Baluchistan (Pakistan); the fluvio-glacial deposits of Potwar; and the great gravel slopes of the Baluchistan Hills (Middlemiss, 1890; Chatterjee, 1960; Kar, 1963; Wadia, 1966; Sastry *et al.*, 1970).

With this introduction at the level of a generalised description of the Pleistocene epoch we have briefly attempted to modulate a physical and environmental background against which the story of mankind in northwest India might have been enacted. For our evidence, however, on the ecological niche to be complete it would be essential to consider the evidence provided by the nature of faunal and floral remains which, despite their apparent specificity, provide intricate explanations which knit together the sequence of events. During the course of our field explorations in the Pinjore we have been able to collect rich assemblages of fossil vertebrates including Proboscidians (*Archidiskodon, Stegolophodont, Elephus*); Suids (larger species of *Dicoryphochoerus, Tetraconodon, Sivachoerus* and *Sus*); Equipds (Equus); Bovids (*Bucapara, Bison*); Giraffids (*Giraffa*); Camelids (*Camelus*); Carnivores (*Crocuta*?) and Rodents (*Rhizomys* and *Hystrix*). Besides these some invertebrate and micro-fossils comprising gastropods, worm tubes and microfloral remains have also been recovered and these are at present under study. While the lower part of the Boulder Conglomerate Formation has generally yielded isolated teeth and limb bones of elephants, the upper parts of these Formations are poorly developed and have yet to yield significant finds.

The Pinjore Formation has a wide geographical distribution; its lithology and rich faunal evidence is indicative of a somewhat wetter and warmer climate. The environment was marked by a reduction of backswamps as the fossil remains of forms like the chelonions, crocodiles and *Hexaprotodon* which were once in great abundance in the Tatrots (pre-Pleistocene), now became scarce. The climate became distinctively colder during the Upper Boulder Conglomerate. This is evidenced from the fact that there was a progressive decrease in the variety of mammalian fauna from the Pinjore to the Upper Boulder Conglomerate. The colder climate may have forced the animals either to take refuge in more congenial environment elsewhere or become extinct.

Further studies on the glaciological fauna in North-West India have been conducted in the Karewas (Kashmir) and Nepal. Among the

fossil vertebrates, the Karewas have yielded the Ungulates (*Rhinoceros and Cervus*) and in Nepal, fossils of Proboscidians (*Archiodiskodon*), Ungulates (Hexaprotodon) and Reptiles (*Crocodilus*) have recently been reported by Gupta (1975). At this level of fossil records from the corresponding pluvial fauna elsewhere in the Indian sub-continent, one draws the inescapable inference that the progressive and widespread reduction of the Śivalik fauna was not confined only North-Western regions but was extended also to the rest of the Indian sub-continent.

A re-enactment of the story of mankind in the Pleistocene of India, assuming it could be managed without the evidence of any human skeletal remains, would be possible from marks of the past impressed upon objects or artifacts by early man. Our first awareness of any such possibility was afforded by a palaeolithic tool recovered near Madras by Robert Bruce Foote in the year 1863, notwithstanding the earlier collections of neolithic tools by Taylor in 1842 and Mesurier in 1861.

The earliest stone age tools of crude description were reported from Kashmir and Punjab and have tentatively been assigned to the Lower Pleistocene (Sankalia, 1974). Earlier large flakes with prominent bulbs suggestive of a Pre-Soan industry of the Boulder Conglomerate were recovered from the basal beds of the Lower Narbada group (De Terra and Paterson, 1939). Referring to these, Sankalia (1974) states that such tools "which constitute the earliest Palaeolithic Culture in India consist of large flakes made from crude split pebbles. All are rolled. The upper surface is generally unworked except for occasional marginal scars, whereas the under surface shows the primary flaked surface with flat bulbs, but large well-developed cones, the striking platforms are simple, unfaceted. There is no secondary working, but the edges are worn out either by nature or by use. Such tools are found near the top of the Boulder Conglomerate at Malakpur, Adial Chauntra, Kallar, Chaomukh and Jammu in Potwar, southeast of Rawalpindi." These tools constitute the earliest known relics of man in India.

Recent researches have established the widespread existence of Stone Age implements ranging from chippings to more skilfully fashioned implements including scrapers, blades, points, celts etc., in the succeeding periods of the Potwar plateau, Kashmir, the Upper Śivalik Boulder Conglomerate and Punjab and in other superficial alluvia in North India.

While engaged in palaeoanthropological researches we sought for earlier relics of man but without being able to discover any positive evidence of the exact geological period including the Pleistocene of the advent of man in the fauna northwestern India. The numerous facts which have been brought to our notice touching the discovery of the *Ramapithecus* in the Miocene and the stone implements in the Pleistocene in association with animal remains constitute important evidence without being conclusive. In reflecting upon the past conditions particularly during the Mio-Pliocene epoch of the habitable areas and assuming the rapid succession of births and deaths one would be led to believe that large areas would become thickly strewn with animal life in the succeeding Pleistocene period. It is, however, no less true than astonishing that remains of generations of animals and men became more and more scarce during this epoch.

Since the Glacial period, while the general configuration of the area has remained somewhat unchanged down to the present times the deposits and geological formation of the Pleistocene in which we could most advantageously study the earliest traces of primitive man, are, in the greatest degree, inaccessible to our investigations largely due to inadequate funding and scientific planning. These deposits are to be found in the Sivaliks, river terraces, alluvial fans and cones, fluviatile accumulations, and sand sheets and fossil desert dunes in Rajasthan. These will hopefully yield satisfactory evidence in favour of the appearance of man in North-West India.

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Environment of Early man in North-West India: Palaeobotanical Evidence

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INTRODUCTION

The inference of former environment from palaeobotanical evidence is dependent upon the plant remains comprising microfossils (pollen and spores) and megafossils (leaves, woods, seeds, and fruits) and their proper identification with modern taxa accompanied by sound knowledge of the various habitats and tolerances of the identified plant taxa or the communities to which they belong. The megafossils provide important and dependable evidence as it is often possible to identify them to plant species which in pollen grains is seldom possible. The inference of past environment requires the reconstruction from the remains of plants of plant communities which are usually in equilibrium with a particular climate. The pollen assemblages derived as they may be from short and long distances usually represent a mosaic of plant communities of different climatic regimes from within and outside the area investigated. To interpret them in terms of past environment, a sound knowledge of ecologically compatible plant species is highly essential together with that of differential production, dissemination and preservation of pollen grains and the possibilities of their derivation from earlier strata. Interpretations in disregard of these factors may often be misleading. Further, it is important to determine if the changes in pollen curves are statistical artefacts or represent factual alterations in vegetation induced by climate (temperature, precipitation, and other meteorological factors), soils and/or biota.

In view of our insufficiency of knowledge of the seasonal distribu-

tion of temperature and precipitation and variations in microhabitats, of the autecology of species and their behaviour in plant communities and of the production, dissemination and deposition of pollen, the inference of climatic changes has necessarily to be of a very broad nature. Inadequate knowledge on these grounds often results in conflicting interpretations. Until more information of the basic data is available, it would be advisable to base environmental inferences on broad vegetational changes for every change in curves may be of local or seral nature or even a statistical artefact.

The environmental significance of palaeobotanical information discussed in an article on similar theme in 1972 (Vishnu-Mittre, 1972b) concerned only the Quaternary Period. More recent research in the Śivaliks has revealed that during more particularly the mid-Tertiary to late Tertiary period (mid-Miocene to Pliocene times) gradual and progressive evolution has taken place among the primates such as the primitive monkeys (*Indraloris*), monkeys (*Papio*), anthropoids (dryopithecines), gorilla-like apes (*Gigantopithecus bilaspurensis*), and finally gibbon-like primates (*Pliopithecus krishnaii*) which comprise precursors to the origin of man (*Homo sapiens*). This structural and behavioural evolution in the precursors of man leading to human emergence and subsequently the behavioural and cultural evolution until the early historical period has largely been governed by alterations in environment.

The present paper therefore discusses the environmental inference from the mid-Tertiary period to the Iron Age as inferred from plant remains. No reference is made to inference of past climate from geomorphological data or any such other parameter which is beyond the scope of the topic discussed here. Palaeobotanical information from the mid-Tertiary to the end of Pliocene from northwest India comprises both of megafossils (Sahni 1964; Lakhanpal, 1965, 1967, 1968, 1969; Lakhanpal and Dayal, 1966; Rawat, 1964, 1964-65; Ghosh and Ghosh, 1958; Varma, 1968; Bhandari *et al.*, 1972; Prakash, 1975) and of microfossils (Banerjee, 1968: Nandi and Bandyopadhyay, 1970; Bhatia and Mathur, 1970; Nandi, 1972: Tewari and Sharma, 1972; Venkatachala, 1972; Singh, Khanna and Sah, 1973; Salujha, 1974). Informatior. on palaeoecology and historical geology from Tertiary plant remains has been published by Randhawa *et al.* (1969); Vishnu-Mittre (1969); Prakash (1973); Lakhanpal (1970, 1974).

It is highly distressing that some important Late Quaternary

profiles from the Kashmir Valley, from the Belon River in Allahabad and from cave sediments in Mirzapur and Bhopal (Lakhaia, Kurha, Bhimbetka, etc.) have been found without pollen. The new information comprises the Weichselian pollen sequences from Nepal (Vishnu-Mittre and Sharma, 1975b, MS) and the late Weichselian dating of the high altitude Kashmir pollen diagram (Gurdip Singh, pers. comm.), the publication of Himachal Pradesh pollen diagrams (Sharma and Singh, 1974a, b), the final publication of the Rajasthan pollen profiles (Singh *et al.*, 1974), the completion of pollen analyses from Nalsarovar and Malvan in Gujarat (Vishnu-Mittre and Sharma, 1975a, 1975c), the pollen analyses of buried soils in Inamgaon in Maharashtra (Vishnu-Mittre and Gupta, 1975), and of mangroves from Bombay (Vishnu-Mittre and Guzder, 1975).

We have thus palaeobotanical information available at the present from three distinct phytogeographical regions in north-western and western India namely the western and central Himalaya, the sandy desert of Rajasthan, and the coastal areas of Gujarat and Maharashtra. Much information is also now available of the cultivars and of wild plant species made use of for various purposes (Vishnu-Mittre, 1974c, d). The palaeoecological information is discussed under appropriate phytogeographical regions.

A. ENVIRONMENT OF EARLY MAN IN NORTH-WESTERN AND WESTERN INDIA

1. North-Western Himalaya

1a. From mid-Miocene to end of Early Pleistocene

The pollen analytical evidence from the Śivaliks is of the preliminary nature firstly because pollen is scarce in the sediments and secondly several kinds of pollen grains and their actual frequencies remain undetermined. These aspects impose serious limitations in assessing their local or extra-local origin and in determining the kind of environment suggested by their presence. General scarcity of microflora in the Sivalik sediments has been observed by Banerjee (1968), Salujha (1974), and H.P. Singh (pers. communication). This scarcity of pollen in sediments is obviously due to the former prevalence of conditions not conducive for their preservation and these and subsequent conditions were responsible for partial or whole

destruction of certain kinds of pollen grains so that the pollen assemblages recovered are highly unsuitable for reconstruction of plant communities and for inference of past environment therefrom. Nandi (1972) has reported that pollen grains from the Middle Śivalik sediments of Mohand (East) Field, Himachal Pradesh, are of local and extra-local origin and some samples are rich in pollen/spores of one or the other kinds of plants – obviously the effect of differential destruction of pollen.

From his palynological studies in Bhakra-Nangal area, Banerjee (1968) concludes that estuarine conditions were prevalent during the Lower Śivalik times as evidenced by *Cocos* type pollen and the vegetation was of a temperate to sub-tropical nature growing in low-lying areas under warm and humid conditions (abundance of angiosperms, and ferns with pollen of *Pinus* spp., grasses and composites). During the Middle Śivaliks the vegetation changed from coastal to inland. A cooling of surroundings took place with uplift of higher ground as suggested by the predominance of Pine pollen, decline of fern spores, and reduction in angiosperm pollen. The climate was cool, dry and temperate during the middle Śivalik times. From studies in the Middle Śivalik sediments of Mohand in Himachal Pradesh, Nandi (1972) concludes that the climate was humid to drier and temperate to sub-tropical from an admixture of pollen grains of diverse ecological requirements and of varying geographical distribution. She further states that the marshes where these pollen grains were deposited received sediments from different geographical horizons and a great climatic change had occurred during their deposition from upper Miocene to Lower Pliocene times.

From a diversified pollen assemblage (comprising pollens of angiosperms and gymnosperms and spores of fungi) with poor frequency of distribution in Middle Śivalik lignite along Bhed Khad, Himachal Pradesh, Nandi and Bandyopadhyay (1970) conclude that the vegetation was fairly rich but most of their remnants had been destroyed by the fungal activity during lignification or due to adverse circumstances during their preservation in sediments.

The unreliability of pollen evidence from the Śivaliks for inference of former climates from technical viewpoint has already been indicated above. It may also be mentioned that Venkatachala (1972) reports several different kinds of pollen grains (Malvaceae, Betulaceae, Anacardiaceae, Pinaceae, and Polypodiaceae) from Middle Śivalik deposits than those recovered by Banerjee (*op. cit.*) whereas Singh,

Khanna and Sah (1973) record absence of pollen in the Lower, Middle and Upper Śivaliks of Bhakra-Nangal area. The latter workers also discovered pollen from the carbonaceous shale of the Pinjore Formation exposed in the vicinity of Chandigarh and conclude subtemperate and/or temperate climate during the Upper Śivalik times in the area of study. The inference is based upon presence of *Pinus*-type pollen, the inaperturate-type pollen and spores of lycopods. It must be remarked that neither the species of *Pinus* (the subtropical or the temperate one) has been identified, nor the local or extralocal origin of conifer pollen considered. In the absence of this information the inference of temperate climate remains unproven. The proportional increase in conifer pollen from Lower to Middle Śivaliks is apparent from these studies indicating that the conifers had migrated to the distantly located higher elevations in response to the gradually cooling climate in the region.

The megafossil evidence from the Lower Śivaliks near Khokhra 2 km south of Nalagarh, Himachal Pradesh (Prakash, 1975) comprises fossil woods comparable to four modern species of *Dipterocarpus* distributed today along the west coast, Bengal, Assam, Andamans, Burma, and South East Asia, of *Cynometra* distributed in Assam and Bengal, of *Milletia* occurring in Assam, and comparable species of the other taxa of wider distribution within the country. Many corresponding modern species with which the leaf impressions from Lower Śivalik beds at Balu-Goloa near Jawalamukhi (Lakhanpal. 1965, 1967, 1968, 1969; Lakhanpal and Dayal, 1966) have been compared are of wider distribution in tropical Himalaya from Kumaon or Garhwal eastwards and some are of still wider distribution in many parts of the country. Of these *Fissistigma wallichii* occurs only in Bangla Desh, Assam, and Sylhet and *Ficus cunia* in the subhimalayan tracts from Chenab to Burma and in Central India ascending up to 1,200 metres. The others occur throughout India. These floras include evergreen and deciduous elements. Remains of Dipterocarps and Bauhinias are also known from the Lower-mid Śivalik deposits at Mohand near Dehra Dun (Rawat. 1964. 1964-65). In the Lower-mid Śivalik beds at Hardwar leaf impressions of *Meliaceae*, *Diospyros*, *Croton*, and *Eucalyptus* have been recognised (Varma, 1968) though the latter is doubtful as the genus has been introduced in the country within the past 100 years.

From the Middle Conglomerate Zone (mid-Śivaliks) west of village Khundian near Jawalamukhi fossil wood assigned to the genus

Anisoptera which occurs today in southern Bengal and Burma has been found (Ghosh and Ghosh, 1958).

The megafossil evidence reveals the local occurrences of a tropical semievergreen forest with an admixture of deciduous forest elements during the Lower Śivaliks with several representatives occurring today in Bengal and Assam suggesting a much wetter and warmer climate* than the present during the mid-Miocene times. The temperatures were more equable (oceanic climate) than they are today. The presence of Diptercarps suggests also montane topography (low hills with gentle slopes). This is amply supported by palynology of these sediments by Banerjee (1968) which particularly provides evidence of ground vegetation comprising Compositae and grasses though the percentages of the latter are not much perhaps due to grazing by the herbivores or the forests had a closed canopy. Migration of conifers had already started to higher elevations located distantly. During the Middle Śivaliks climate became continental, less warmer, and less wetter than during the Early Śivaliks. This is supported by rare occurrence of pteridophytes and the progressive immigration of conifers still distantly located at higher elevations. The absence of ground vegetation as stated above may be ascribed to increased grazing activity by the herbivores or to the closed canopy of forests.

During the Tatrot stage the occurrence of sheets of fresh water is indicated by discovery of several taxa of Charophytes (Bhatia and Mathur, 1970; Tewari and Sharma, 1972).

The increase in gymnospermous pollen possibly of *Larix* (personal discussion with H.P. Singh) and *Pinus* in the Pinjore Formation is highly suggestive of a cooler and moist climate. The role played by the uplift of the hill ranges on climate and over-all environment cannot be overlooked. Comparatively low heat and less humidity characterised the climate and the temperate climate occurred very distantly. The insufficient identification of pollen grains and their extra-local status and bulk of tropical megafossils does not permit the acceptance of es-

*The corresponding tropical semievergreen forest with more or less similar generic composition as known from megafossils occurs on flat ground and in hilly country in Bengal, Assam under 100 m altitude with rainfall from 1500-3000 mm (av.2000 mm) and high humidity with the dry season being short or moderated by proximity of sea, the annual mean minimum temperature being 19-20°C and annual mean maximum being 24-25°C (Chapman. Sir Harry G. and Seth. S.K. 1968. A revised survey of Forest types of India, Delhi). More or less similar climatic conditions may be visualised during the mid-Miocene times in the present Śivalik range in NW India.

tablishment of temperate climate until the beginning of the glacial epoch though decline in temperature seems indicated preceding it. It has been suggested elsewhere (Vishnu-Mittre, 1965) that the beginning of Pleistocene (Pinjore Formation) in western India was not coeval with the glacial epoch (Boulder Conglomerate Zone) and it seems to have been amply supported by geological, palaeontological, and palaeobotanical studies. During the interval of time between these two events there had most probably occurred gradual worsening of climate which eventually culminated in the First Glaciation.

In the Kashmir Valley fresh attempts have been made recently to investigate the stratigraphy of the Lower Karewas by the Geological Survey of India (data unpublished yet) and by Farooqi and Desai (1974). It must be reported that the samples collected and investigated earlier from the Lower series of Karewas in the Rimbiara valley and from Shopian now designated as Pokharpura Formation and Shopian Formation by Farooqi and Desai (*op. cit.*) were found without pollen. In these formations Farooqi and Desai have described a sequence of at least three glacial and interglacial periods. The renewed stratigraphical studies, it is hoped, would establish the validity of the correlation of sections attempted earlier by de Terra and Paterson (1939) which, with sight modification, constitutes the basis for the environmental inferences from their pollen analyses (Vishnu-Mittre, Singh and Saxena, 1962; Vishnu-Mittre, 1972a, 1973a).

The megafossils comprising leaves of oaks and *Salix* have been found sparingly in Lithozones I-III though more profusely and belonging to several taxa in Lithozone IV (oaks are absent at Ningle Nullah) of the Lower Karewas (Vishnu-Mittre, 1972a). These four Lithozones have been recognised in the stratigraphy of the Lower Karewas by de Terra and Paterson (*op. cit.*). The megafossils particularly from Lithozone IV were interpreted to suggest a tropical or subtropical climate (temperate from Ningle Nullah megafossils) by Puri (1957) but their ecological reconsiderations have allowed inference of moist temperate climate (Vishnu-Mittre. 1965). The paucity of conifers is a notable feature in the megafossils though their occurrence in good frequencies has been discovered from pollen analysis of the impression bearing sediments (Vishnu-Mittre and Robert, 1973). Thus a regional picture of vegetation is imparted by pollen evidence and the local by megafossils suggesting that the broad-leaved forest (the oak woods) perhaps had occupied low lying depressions between folds of mountains as they do today with the conifers occurring on

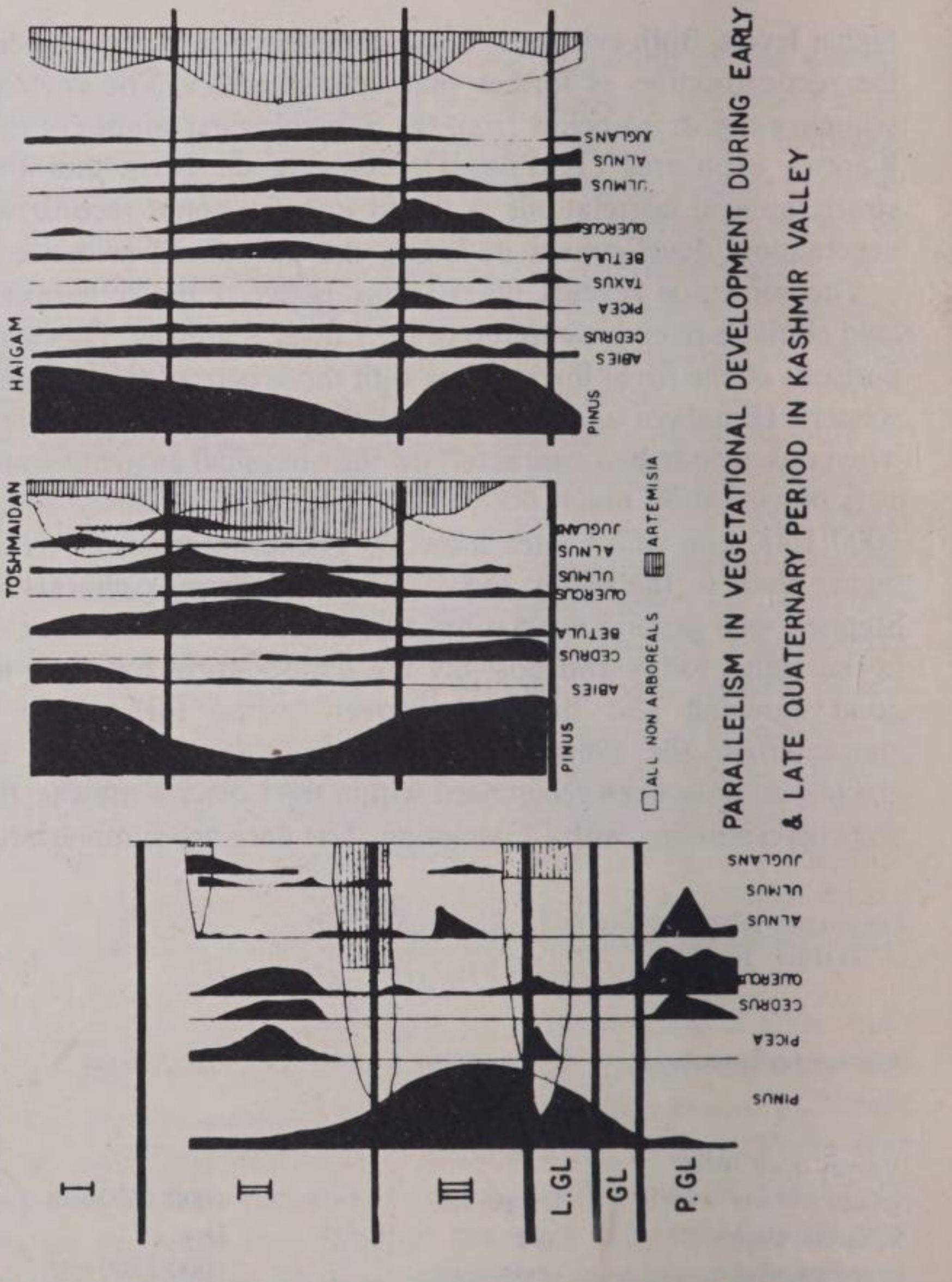
higher levels. Both evidences being complementary aid considerably in the reconstruction of former plant communities. The environmental sequence discussed below from the palynological studies of the Lower Karewa exposures (Text-fig. 1) following de Terra and Paterson's stratigraphical correlations is based upon regional reconstruction of vegetational development including the megafossil evidence also.

The sequence reveals fluctuations between moist temperate and cold climates from base to top of the Lower Karewas. The broad comparisons of the fossil forest types with those occurring elsewhere in the western Himalaya allow us to infer that the moist temperate periods when oak woods had characterised the botanical environment had annual precipitation much above the present in the valley and around 1000-1500 mm with winter snowfall. The temperatures were about 3° higher than in the valley today. The cold periods characterised by Steppe (open ground vegetation) had a severer climate than obtained in the valley today and possibly the temperatures too were lower. A good snowfall and the snow cover lasting for several months characterised the climate. Two cool oscillations (indirect effect of glaciation) have been recognised within the Lower Karewas, the lower one corresponding with I Glaciation. The data are summarised below.

Environmental succession in the Lower Karewas
cf. Text-fig. 1

Botanical environment	*Temperature*	*Precipitation*
Walnut open forest Spruce-Deodar woods Subarctic steppe	Temperate cold	1000-1300 mm Dry
Blue Pine woods	Temperate	1000-1300 mm Good snow fall in winter
Subarctic steppe*	cold	Dry
Oak-Alder-Deodar woods†	Temperate	1000-1500 mm snow lying for several weeks

*The beginning of the Glacial Epoch in the Kashmir Valley has been suggested here and the beginning of the Pleistocene at the base.
cf. Vishnu-Mittre 1973a and 1974e.



Text-fig. 1. In the early Quaternary pollen diagram from the Lower Karewas shown on the extreme left in the Text fig. the two cool oscillations are indicated by tremendous increase in the nontree pollen grains. The postglacial vegetational development at Toshmaidan and Haigam reveals more or less the same pattern as in the Lower Karewas. The beginning of the postglacial vegetational development was shown corresponding with a cool oscillation in this diagram constructed in 1966 (Vishnu-Mittre 1966) though interpreted then to date from the beginning of Holocene in view of confusion caused by the interplay of pollen grains. The interpretation of a clearance phase at the base of Haigam diagram led my subsequent conservative dating of these Postglacial diagrams to the Neolithic (3000 B.C.) subject however to the final verdict by Carbon-14 determinations. The radiocarbon verdict now available in regard to the Toshmaidan diagram dates its beginning to Late Glacial (see text) (After Vishnu-Mittre 1966).

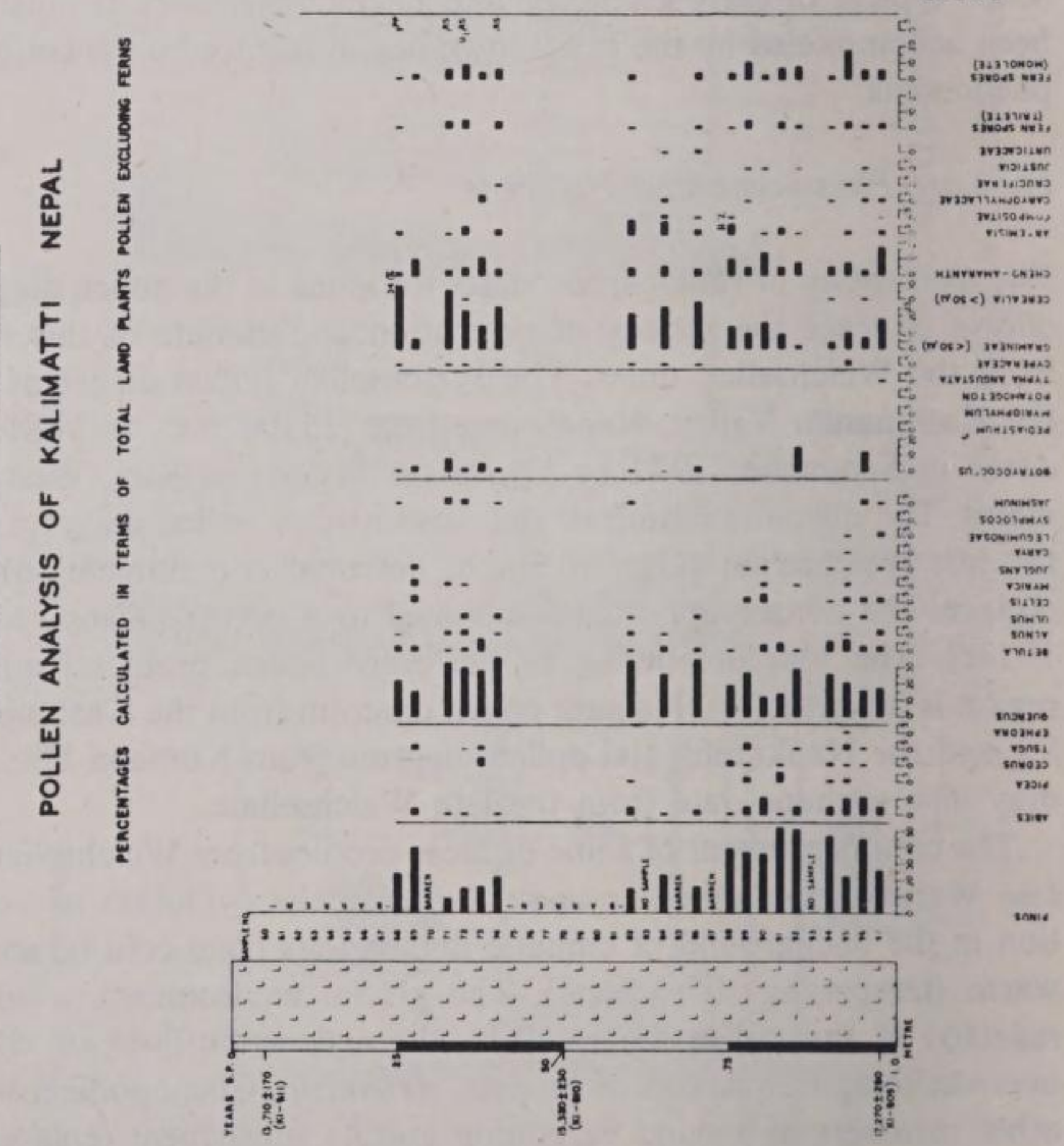
The cold phases with severe climatic conditions were characterised by breakdown of continuous forest cover and by spread of grassland rich in *Artemisia*, Chenopodiaceae, etc., giving a subarctic park landscape typical of early-glacial or late-glacial vegetation. It must have been accompanied by the breakdown of soil surface by the periglacial phenomena.

1b. Late Pleistocene and Holocene

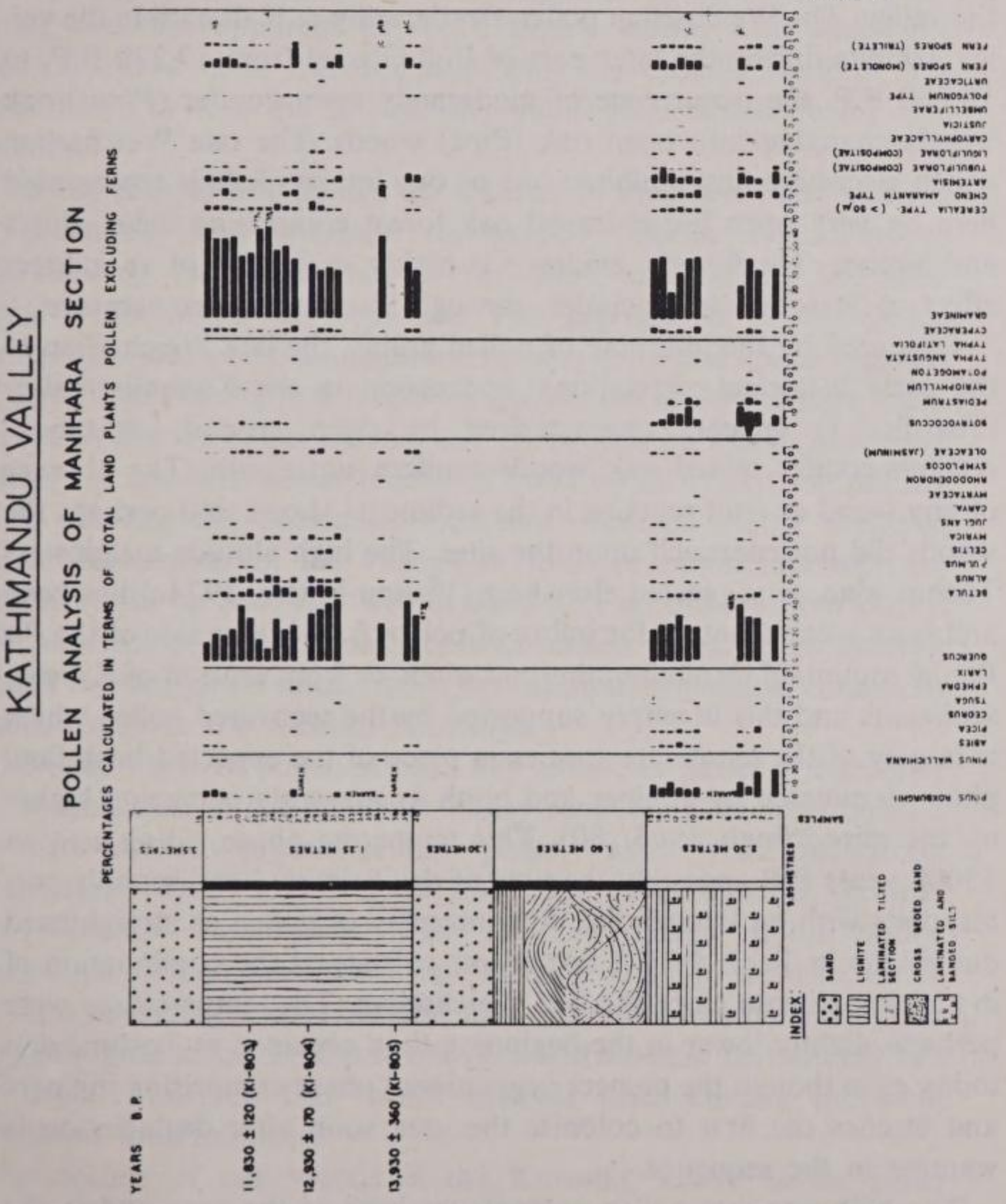
The availability of radiocarbon dates for some of the pollen diagrams allows us trace the history of vegetation and climate of this region from the Weichselian times. The Weichselian pollen diagrams from the Kathmandu Valley, Nepal, date from 15300 B.C. to 9880 B.C. dated in September 1974 by Dr. H. Willkomm at Kiel, West Germany. The absolute dating of the Toshmaidan pollen diagram from the late Weichselian (Gurdip Singh, personal communication) now replaces the conservative dates assigned to it earlier (Vishnu-Mittre, 1974c). The absolute dating of the other pollen profiles from this region is awaited. The Haigam pollen diagram from the Kashmir Valley and the Naukutchiyatal pollen diagram from Kumaon Himalaya may also perhaps date from the late Weichselian.

The commencement of some of these profiles from Weichselian and late Weichselian impresses upon the mind the evolution of vegetation in the background of climatic fluctuations from cold (glacial) to warm (temperate, subtropical). The glacial environment would be reflected in the pollen diagrams by the articalpine flora or else by overwhelming frequencies of grasses, *Artemisia*, Chenopodiaceae and other members of ground vegetation and its subsequent replacement by the temperate or subtropical flora. The latter is apparent in these pollen diagrams though high values of ground vegetation indeed occur highly obscured by the accompanied pollen grains of temperate trees transported or derived from elsewhere and at Toshmaidan particularly from the valleys on the south and north of the Pir Panjal. For palaeoecological inference especially it is essential to understand the interplay of pollen grains in terms of mosaic of plant communities which might have occurred in several habitats such as aspect, slope, depressions, ravines, and banks of marshes, lakes and water courses, etc., provided by montane physiography.

The Nepal diagrams (Text-figs 2, 3) are from the subtropical region of the Kathmandu Valley. The high ground vegetation pollen seen here



Text-fig. 2. The Weichselian Pollen diagram from Kalimatti, Kathmandu Valley (After Vishnu-Mittre and Sharma 1975). (Biostratigraphy not indicated.)



Text-fig. 3. The Weichselian-Late Weichselian pollen diagram from Manihara, Kathmandu Valley. (After Vishnu-Mittre and Sharma 1975). (Biostratigraphy not indicated.)

is consistent with the botanical definition of indirect effect of glaciation suggesting that the ice during the last glaciation did not encroach upon the valley. The Weichselian pollen stratigraphy at Kalimatti in the valley exhibits during the later part of Full Glacial from 17,270 B.P. to 15,300 B.P. the occurrence of moderately open conifer (*Pinus*)-oak woods changing into open oak (Pine) woods. The late Weichselian which elsewhere has exhibited one or two interstadials is represented here by very open broad-leaved oak forest comprising oaks, alders and birches. The floristic evidence is highly suggestive of an indirect effect of Weichselian glaciation through lowering of temperature.

Obscured by the interplay of pollen grains, the late Weichselian to the early historical vegetational succession in the Kashmir Valley (Text-fig. 1) appears characterised by open ground vegetation-conifers-conifer mixed oak woods-conifers succession. The absence of any wood or fruit remains in the sediments shows that perhaps the woods did not encroach upon the sites. The high altitude meadow at Toshmaidan as suggested elsewhere (Vishnu-Mittre, 1974c) has been and is an ideal situation for influx of pollen from either side of the Pir Panjal mountain through upthermic winds or from erosion of Karewa sediments and this is amply supported by the recovered pollen which is largely of the temperate species in place of the expected bush land phase dominated by Juniper and birch as presently occurring higher up the mire (Singh 1963: 80). This temperate phase subsequent to 15000 years B.P., possibly the time of deglaciation here, broadly corresponds with an interstadial. The interplay of pollen as straightened out by me in Table IV Cf. text seems to suggest the continuation of dry alpine climate since the late Weichselian. The temperatures were perhaps slightly lower in the beginning than obtained at Toshmaidan today even though the pioneer vegetational phase comprising junipers and birches the first to colonise the area soon after deglaciation is wanting in the sequence.

The high non-tree pollen percentages both at the base and in the large part of the Kashmir pollen diagrams (Text-fig. 1) are highly suggestive of local environmental conditions. High values of Chenopodiaceae and of *Artemisia* are indicative of dry climate, poor precipitation and winter precipitation being in the form of good snowfall which covered the ground through a large part of the year but for summer months. The forests were largely open. The precipitation was around 600 mm per year. If the undated Naukutchiya Tal pollen diagram in the Nainital district is also by

analogy believed to date from the late Weichselian or the early Holocene, the establishment of the comparatively cooler subtropical climate becomes apparent by the Chirpine woods with which the sequence opens here. Subsequently with the establishment of oak woods more or less the present-day subtropical climate came into existence.

The interplay of tree pollen, the absence of their seeds and fruits in the sediments and montane topography impose limitations in understanding the occurrence of the plant associations and their mutual successional development. The segregation of the pollen assemblages into plant associations in both time and space suggests that the Pines, the light demanders, readily occupied the bare areas released by the ice or permafrost and pinewoods on well-drained sites possibly on northern slopes tended to build up their own soil profiles rich in humus; the deciduous members occurred in the sheltered moister depressions in the valleys or folds of mountains with the evergreen oaks on base rich well-drained sites on the southern slopes. Their succession or predominance was indeed governed by suitable edaphic developments under more or less similar climatic conditions as seen today in the western Himalaya.

The occurrence of pollen of oaks and alders, the latter in extremely poor frequencies, in the Kashmir Valley remains to be determined if they were factually present or their pollen was derived from distant transport or incorporated from the Lower Karewa sediments. *Quercus ilex-Artemisia* community was inferred based upon pollen assemblage, though more positive evidence ought to be discovered. The high percentages of *Artemisia* and other montree pollen suggest very open ground cover and if the *Q. ilex-Artemisia* community has been rightly inferred this would indicate drier climate prevalent throughout the Holocene.

The decline of oak woods in the Kashmir Valley as the radio carbon dates would have us believe took place some time during the sub-Boreal and not as late as 500-700 A.D. the event dated in Himachal Pradesh and as believed earlier (Vishnu-Mittre, 1966, 1974c). This decline by human influence for fuel and fodder and possibly for cultivation is apparent in the Himachal pollen diagrams but among the combination of factors increasing aridity in climate cannot be overruled for this decline in the Kashmir Valley diagrams. In most parts of the world optimal conditions in warmth and dryness had developed during the sub-Boreal. High values of pollen of

Artemisia plants which are believed to be characteristic of dry steppes are suggestive of sub-Boreal being dry here too.

The role of physiography upon climate particularly in the Kashmir Valley in the western Himalaya cannot be overlooked. In view of the low altitude of the Pir Panjal mountain during the Pleistocene, the early Pleistocene vegetational development as observed in the Lower Karewas was influenced by the full impact of monsoon as it occurs in the Jammu State and the total precipitation must have been around 1000-1500 mm per annum including that of the Mediterranean. Subsequent to the uplift of the Pir Panjal during the second glaciation to such heights as to become an effective barrier to the monsoon the vegetational succession in the Kashmir Valley has been governed by a weak monsoon about 500-600 mm per annum. This is amply supported by the pollen analytical studies carried out in the Kashmir Valley.

The botanical environment in the western Himalaya since the Weichselian times is shown in Tables I-IV Cf. Text-figs.1-3. The genera shown within brackets in these tables are largely believed to be extra-local or extra-regional in nature and advantage is taken of this fact in the inference of broad picture of former environment from pollen analytical data. The occurrence of plant species of some of these genera in varying habitats provided by mountainous physiography at various heights, in the sheltered localities between folds of mountains, along river courses, etc., cannot be overlooked. The Kashmir Valley sequences stand apart from those of the rest of the western Himalaya in several respects more particularly in the development of vegetation here under the impact of feeble effect of monsoon. The precise environmental inference will gradually become possible after we have properly segregated the plant communities from their mosaic in pollen assemblages and when our knowledge of their ecology has advanced sufficiently.

2. Rajasthan Desert

2a. Holocene

The climatic fluctuations during the Holocene have been inferred from pollen diagrams by Singh *et al.* (1974). Based upon the pollen grains of supposedly wet climate indicators the Holocene climate in Rajasthan has been inferred to have comprised (Singh *et al.*, *op. cit*) ex-

tremely severe arid climate with strong winds prior to 10,000 BP; 25 cm more rainfall during 10,000-9500 BP when a westward shift of rainfall during 9500-5000 BP; a dry arid period between 3800-3450 BP, when the lakes started drying up and finally the amelioration of climate around (?) early centuries A.D. to the present.

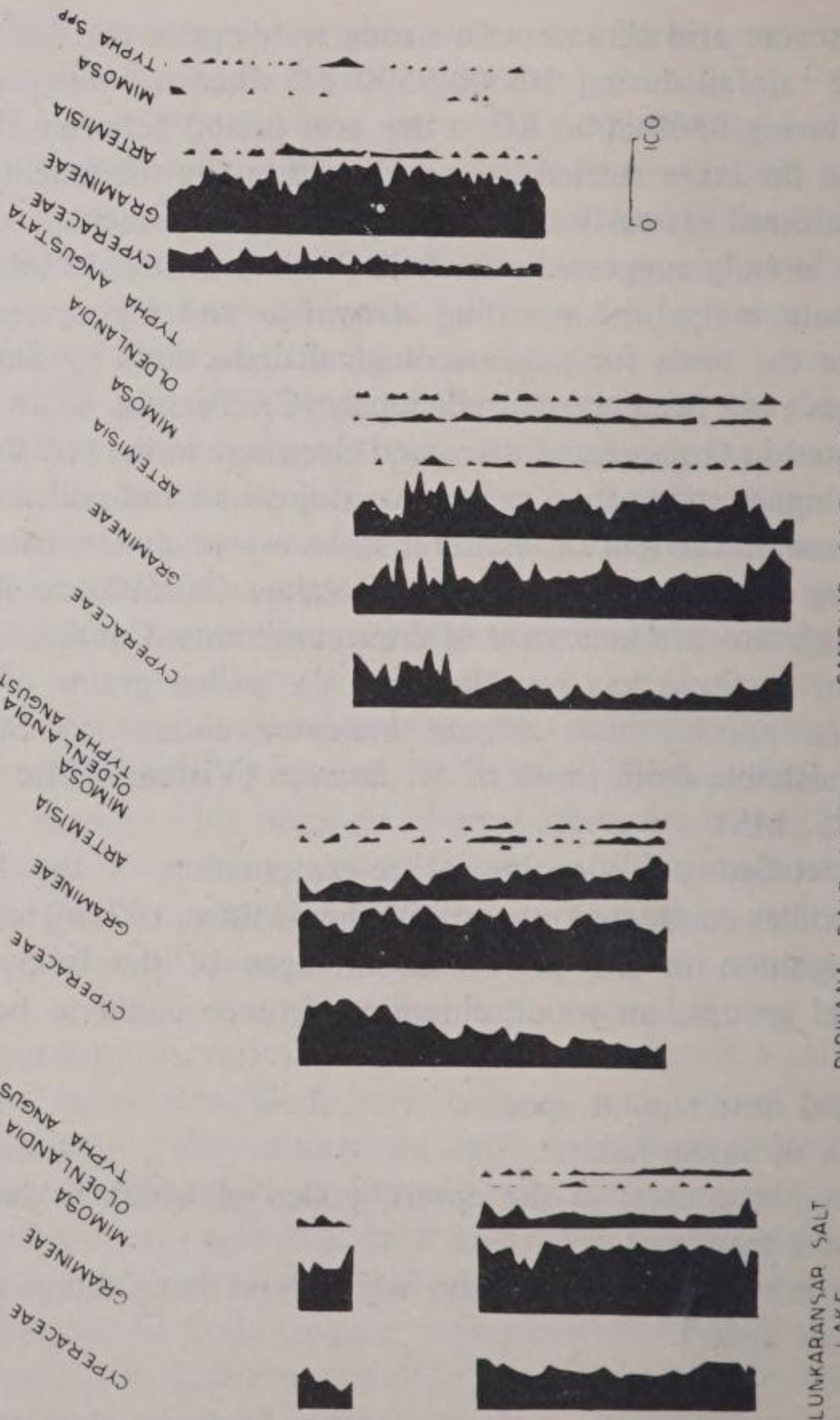
I have already suggested elsewhere (Vishnu-Mittre, 1974b) that the wet climate indicators including *Artemisia* and Cyperaceae which constitute the basis for palaeoecological deductions by Singh *et al.* (1974) have not been chosen judiciously (Cf. Text-fig. 4). In the areas investigated in Gujarat and discussed elsewhere in the text the rainfall is much higher today than in western Rajasthan and pollen curves of Cyperaceae and *Artemisia* continue to be extremely low (under 10%) suggesting once again that their high values (20-50%) in Rajasthan pollen diagrams are indicative of drier conditions. Continued work at the Sahni Institute has revealed that the pollen grains of *Mimosa rubicaulis*, another wet climate indicator chosen by Singh, are indistinguishable from those of *M. hamata* (Vishnu-Mittre and Saxena, 1975, MS).

The detailed palaeoecological re-examination of the Rajasthan pollen profiles conducted recently (Vishnu-Mittre, 1975a), has allowed the recognition in the pollen assemblages of the following four ecological groups, on which climatic inference ought to be based:

1. Typical desert plant species.
2. Plants of saline habitat.
3. Plants not present in the desert, pollen of which is due to long distance transport.
4. The fresh water plant species which have been found to be salt tolerant also.

The Holocene sequence of the reconstructed desert plant societies in the dated profiles from Lunkaransar, Didwana and Sambhar salt lakes together with environmental inference is set out in Table V cf. Text-figs. 5-7. The high non-tree pollen constituted largely by sedges, grasses, and *Artemisia* is highly indicative of much open desert vegetation suggesting the occurrence of dry climate throughout the Holocene. In the light of low pollen production of trees and shrubs, the overwhelmingly high pollen percentages of ground vegetation may not be really that factual as they seem.

The reconstructed desert plant societies belong to two series – the

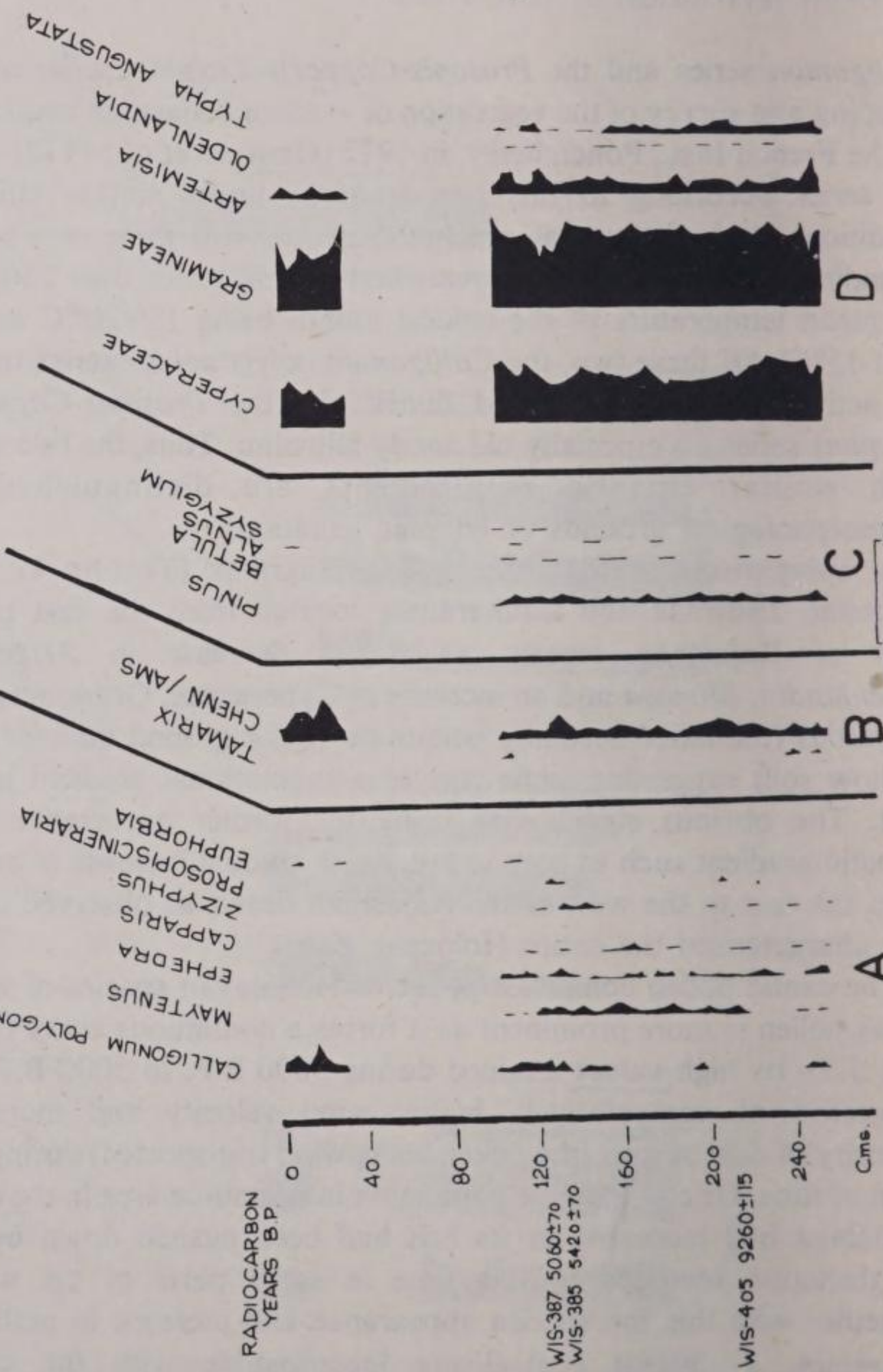


Text-fig. 4. Pollen curves of the wet climate indicators chosen by Singh *et al.* (1974) are shown at the sites investigated including from Pushkar lake which shows development of tropical dry deciduous forest with elements of thorn forest. The chronological arrangement of the pollen curves from individual sites is after Singh *et al.* (1974) Cf Text-figs. 5,6,7. The pollen frequencies of *Artemisia*, *Oldenlandia* and *Mimosa* show an increasing gradient from west to east of the Rajasthan desert whereas Cyperaceae and Gramineae show decreasing gradient Cf. Text. Data after Singh *et al.* (1974).

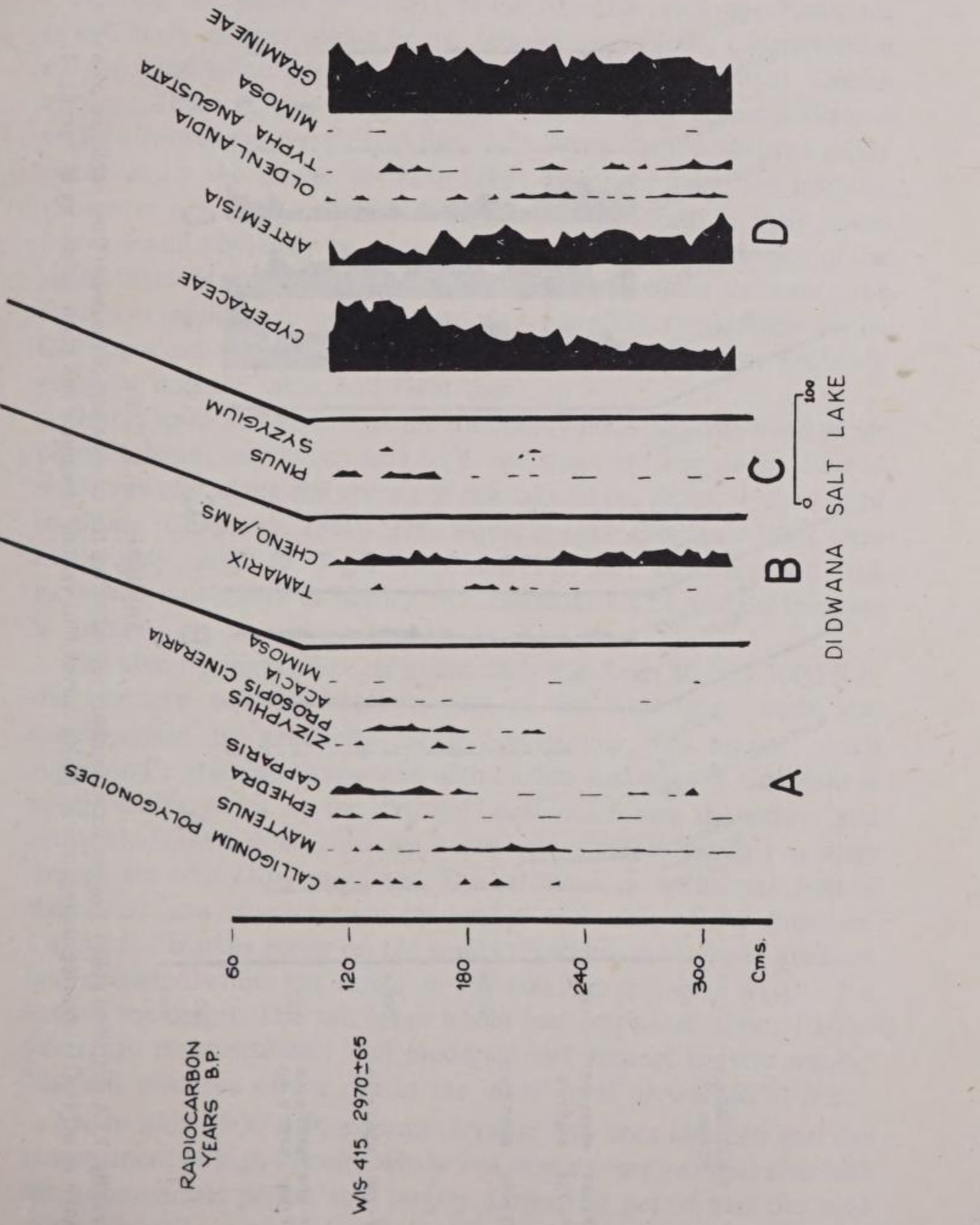
Calligonum series and the *Prosopis-Capparis-Ziziphus* series as per mapping and survey of the vegetation of western Rajasthan conducted by the French Inst., Pondicherry, in 1972 (Gaussen *et al.*, 1972). Both the series according to this survey occur under similar climatic conditions such as annual precipitation 150-400 mm; dry period extending over 9-11 months a year; xerothermic index over 250; and the mean temperature of the coldest month being 15°-20° C or less than 15° C. Of these two, the *Calligonum polygonoides* series occurs on active and stabilised sand dunes and the *Prosopis-Capparis-Ziziphus* series on especially old sandy alluvium. Thus, the two series with similar climatic requirements are distinguished on geomorphological grounds or edaphic situations.

A comparison of the three pollen diagrams (Text-fig. 4) from Sambhar, Didwana and Lunkaransar located from the east to the west of Rajasthan reveals a gradual decrease in *Artemisia*, *Oldenlandia*, *Mimosa* and an increase in Cyperaceae, Gramineae and *Maytenus* (the latter normally occurs on rocky ground covered with shallow soil) suggesting some sort of a vegetational gradient in the past. The obvious significance being the former occurrence of a climatic gradient such as seen today, i.e., a gradual increase of aridity from the east to the west of the Rajasthan desert as observed today had characterised the entire Holocene also.

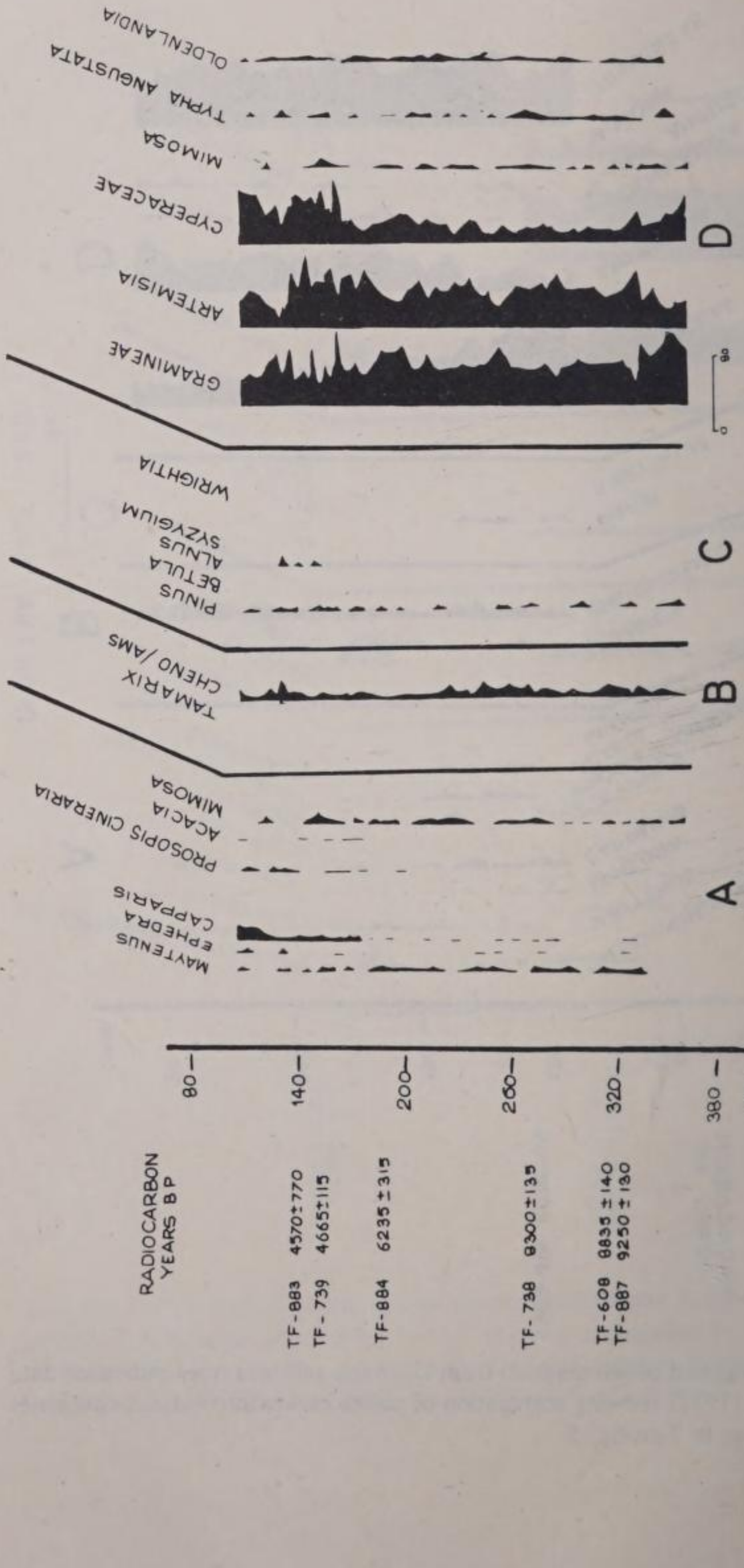
The exotic pollen comprises pollen of Himalayan species of which *Pinus* pollen is more prominent as it forms a continuous curve (Text-figs. 5-7). Its high values attained during 5000 B.P. to 3000 B.P. are suggestive of comparatively higher wind velocity and increased intensity of dust storms (the pollen being wind transported) during this span of time. Or else the pine population in its source area in the outer Himalaya had increased or its belt had been pushed down by the neoglaciation recorded at this time in some parts of the world. Together with this the sudden appearance and increase in pollen of *Syzygium*, a distinct ecologically incompatible with the desert vegetation, is highly suggestive of the transport of its pollen from elsewhere through increased aeolian activity and environment of intense dust storms. The over-all increase in pollen of trees, shrubs, grasses, and sedges during this period of time can only be ascribed to the environment of increased wind velocity and intense dust storms. These facts allow us to infer that during 5000 B.P.-3000 B.P., corresponding with the hypsithermal period, the climate in western Rajasthan was characterised by considerable aridity and intense aeolian activity.



Text-fig. 5. A simplified pollen diagram from Lunkaransar in the extreme west from published data after Singh *et al.* (1974) showing segregation of pollen curves into various categories. A, the prominent desert plant species; B, the species of saline habitat; C, exotic plants; and D, the wet climate indicators.



Text-fig. 6. A simplified pollen diagram from Didwana salt lake from published data after Singh *et al.* (1974) showing segregation of pollen curves into various categories of plant species as in Text-fig. 5.



Text-fig. 7. A simplified pollen diagram from Sambhar salt lake from the extreme east of the desert from published data after Singh *et al.* (1974) showing segregation of pollen curves into various categories as in Text-fig. 5.

Among the plants preferring saline habitats such as chenopods (most likely mother plants being *Atriplex crassifolia*, *Chenopodium album*, *Haloxylon* spp, *Salsola foetida*, *Suaeda fruticosa*), *Cressa cretica*, *Tamarix* spp, some grasses and sedges, Chenopodiaceae make a consistent curve (Text-figs. 5-7). Some chenopods even today occur along the shores of these lakes, Sambhar lake, for instance (Singh *et al.*, 1974. .481). The increase or decrease in their pollen curve would obviously be suggestive of recession or expansion of the saline lakes. Had their seeds been discovered in the lake sediments, the evidence would have been foolproof. A simultaneous decline in the Chenopodiaceae curve observed around 6000 B.P. most probably suggests that the lakes had risen then.

Both *Typha* and *Potamogeton* commonly believed to be fresh water plants tolerate salinity up to 1.83% and these are known to occur in shallow water along the shores of salt lake in the desert southwest of Baghdad (Chapman, 1960). This would suggest that these lakes were moderately salty to begin with and the salt concentration had increased much later in history as a consequence of gradual increase in aridity.

The above criteria allow us to conclude that from 10,000-5000 B.P. the northern and northeastern part of the Rajasthan desert was characterised by gradually rising temperature and aridity which supported a grassland savannah with bushes and trees of *Calligonum polygonoides* series in the extreme west colonising the active and established sand dunes. Rocky areas with shallow sandy soil were overgrown with *Maytenus* trees. The savannah in the eastern part of the desert was characterised by bushes and trees of the *Prosopis-Capparis-Ziziphus* series on old sandy alluvium. A moisture gradient had occurred within the range of 150-400 mm from the west to the east of the desert. The salt lakes which had originated about 10,000 years ago most probably had moderate salt content in their waters. There is evidence of the rise in the lakes' level around 6000 B.P.

From 5000-3000 B.P. extreme dryness had been attained and the environment of high velocity winds and dust storms had characterised the hypsithermal period. It is largely during this period that the sand dune formation activity had intensified and had already encroached upon the northeastern tracts of the desert at Didwana, for instance.

The progressive evolution of desert vegetation to *Calligonum-Capparis* Society in the vicinity of Lunkaransar and of *Capparis-Prosopis-Acacia-Ephedra* Soc. in the vicinity of Sambhar was indeed

the result of increasing aridity, spread of aeolian sands and the extension of dune formation activity. This large-scale desertification was caused by not only the climatic worsening but also by the overall biotic influence (overgrazing, cutting, and burning of vegetation). Subsequent to 3000 B.P. the intensity in high velocity winds and dust storms was reduced comparatively.

3. Kutch, Gujarat and Maharashtra

3a. Pliocene

From the palynological studies of the Pliocene sediments from the vicinity of Naera and Baraia area of Kutch, Mathur and Mathur (1969) conclude a tropical to subtropical climate during the Pliocene times with the prevalence of near coastal and xerophytic conditions. Spores and pollen grains of Gleicheniaceae, Polypodiaceae, Hymenophyllaceae, *Selginella*, *Lycopodium*, grasses, palms and of chenopods recovered by them are indicative of tropical climate with patches of salt marshes and more or less flat regional topography.

The discovery of fossil woods resembling *Dipterocarpus* (Ghosh and Ghosh, 1959), *Podocarpus* cf. P. wallichiana found today in Assam and south of Nilgiris (Lakhanpal, Guleria and Awasthi, 1976) and those resembling Palms, Dipterocarpaceae, Combretaceae, Leguminosae and Sterculiaceae (personal communication by J.S. Guleria) suggest the existence of tropical humid climate during the Pliocene in Kutch.

3b. Late Pleistocene and Holocene

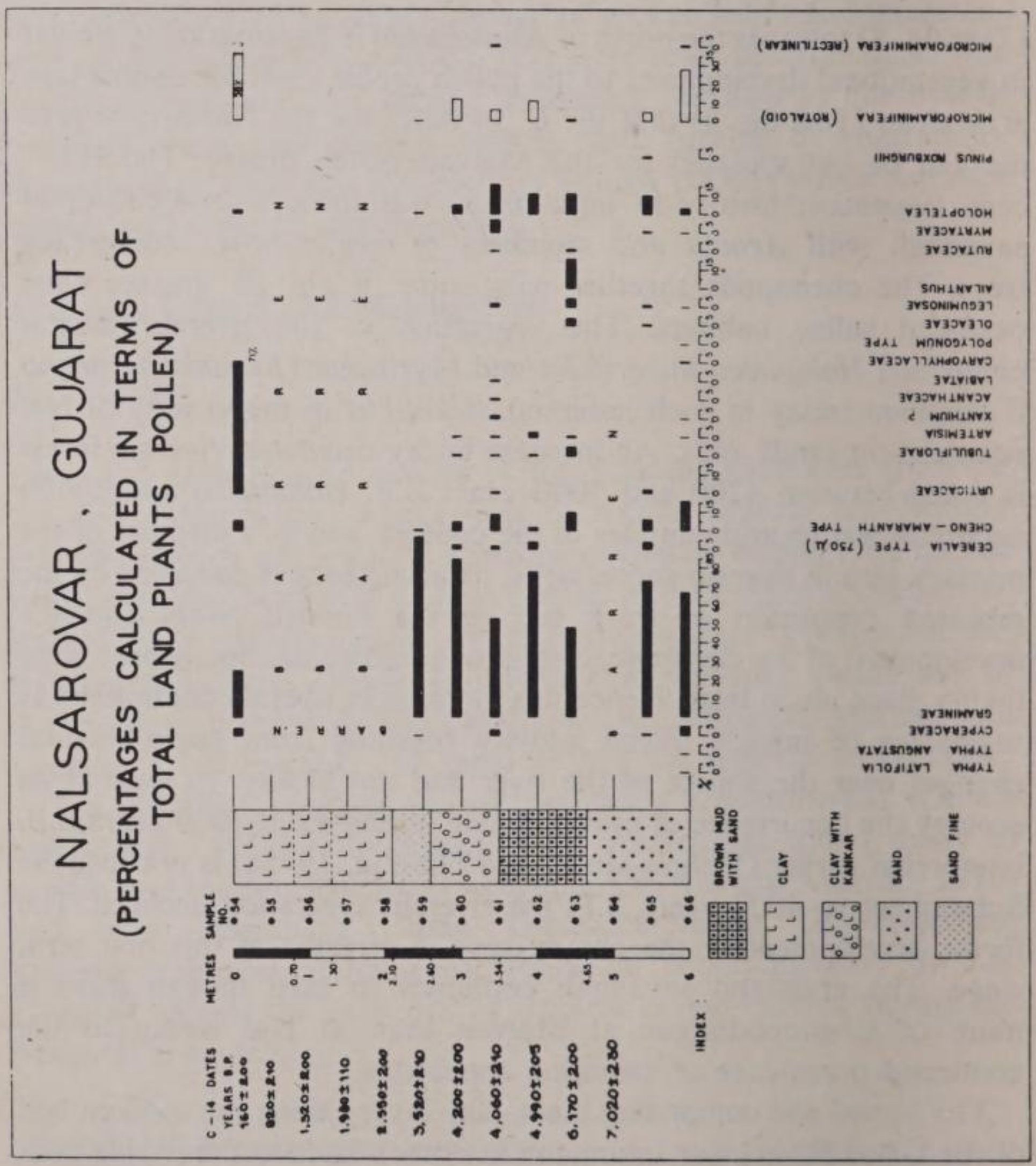
Wood of *Terminalia arjuna* dated to 31000 years B.P. by radiocarbon and discovered from Mula Dam near Pune is suggestive of riverain environment as this species occurs along the banks of rivers throughout the greater part of the Indian Peninsula. Leaf impressions of *Ficus glomerata* and *Ficus arnottiana* from the calcareous tuffaceous strata in the hills around Sangamner, the Pravara river basin, district Ahmednagar, Maharashtra, suggest a semi-arid climate, montane topography and riverain environment (Mahajan and Mahabale, 1972 Cf. Vishnu-Mittre, 1974c).

The Holocene pollen profile from brackish water of Nalsarovar

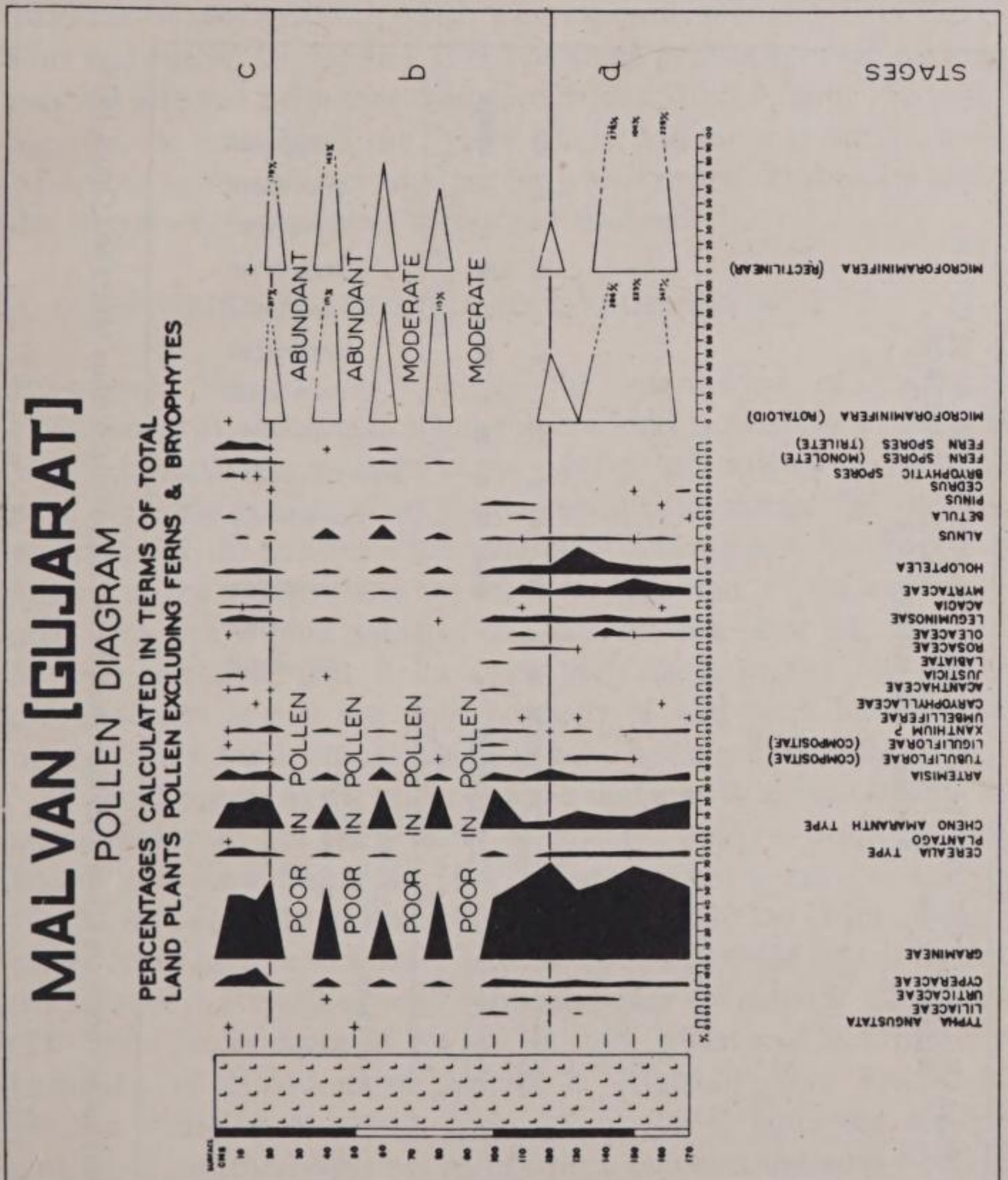
(Text-fig. 8) towards the north of Ahmedabad is so remarkably similar in vegetational development to the pollen profile from the oxbow lake at Malvan (Text-fig. 9) that the C 14 dates for the Nalsarovar profile can be extrapolated for the Malvan pollen profile. The Holocene vegetation history in both begins with the grassland-chenopod savannah with *Acacia* and members of Leguminosae comprising trees. The chenopods together with some, if not all, grasses had occupied saline habitats. The vegetation of the riverain habitat comprised *Holoptelea integrifolia* and Myrtaceae (*Eugenia heyneana* is common today in such habitats). *Ailanthus* in the vicinity of Nal occurred on sandy soils. An increase in dry deciduous riverain forest is noted between 4200 and 7000 years B.P. *Holoptelea integrifolia* occurs in wet to arid climates in the country and as a member of the primary sere in riverain successions, its occurrence is governed by the repeated deposition of fresh silt by the flooded rivers and the development of the climax vegetation of a particular climate prevailing taking place much later. Hence this increase in riverain community is suggestive of intense fluvial activity resulting from environmental changes near the source of the river and not locally. In view of its ecology the occurrence of moist climate during 4200-7000 years B.P. interpreted earlier (Vishnu-Mittre and Sharma, 1975a) is not tenable. Subsequent to 4000 years B.P. the riverain vegetation declines. The forest development of the climax type is arrested at this first seral stage. The grassland savannah continues to exist though there is more of Chenopodiaceae at Malvan than at Nal owing to the continued prevalence of estuarine conditions.

The buried soil comprising black clay layers along the modern bed of the Ghod River near Inamgaon are much later to the pebble conglomerate dated to 19-20,000 B.C. (TF-1003, 21725 ± 630/585, i.e., 19775 B.C.) lying much below it. The pollen spectra (Text-fig. 10) are dominated by *Holoptelea* forest in the vicinity and along the banks of the Ghod River. *Acacia* was the other tree of this deciduous forest. A dry climate such as at present at Inamgaon with precipitation around 500-600 mm has been inferred.

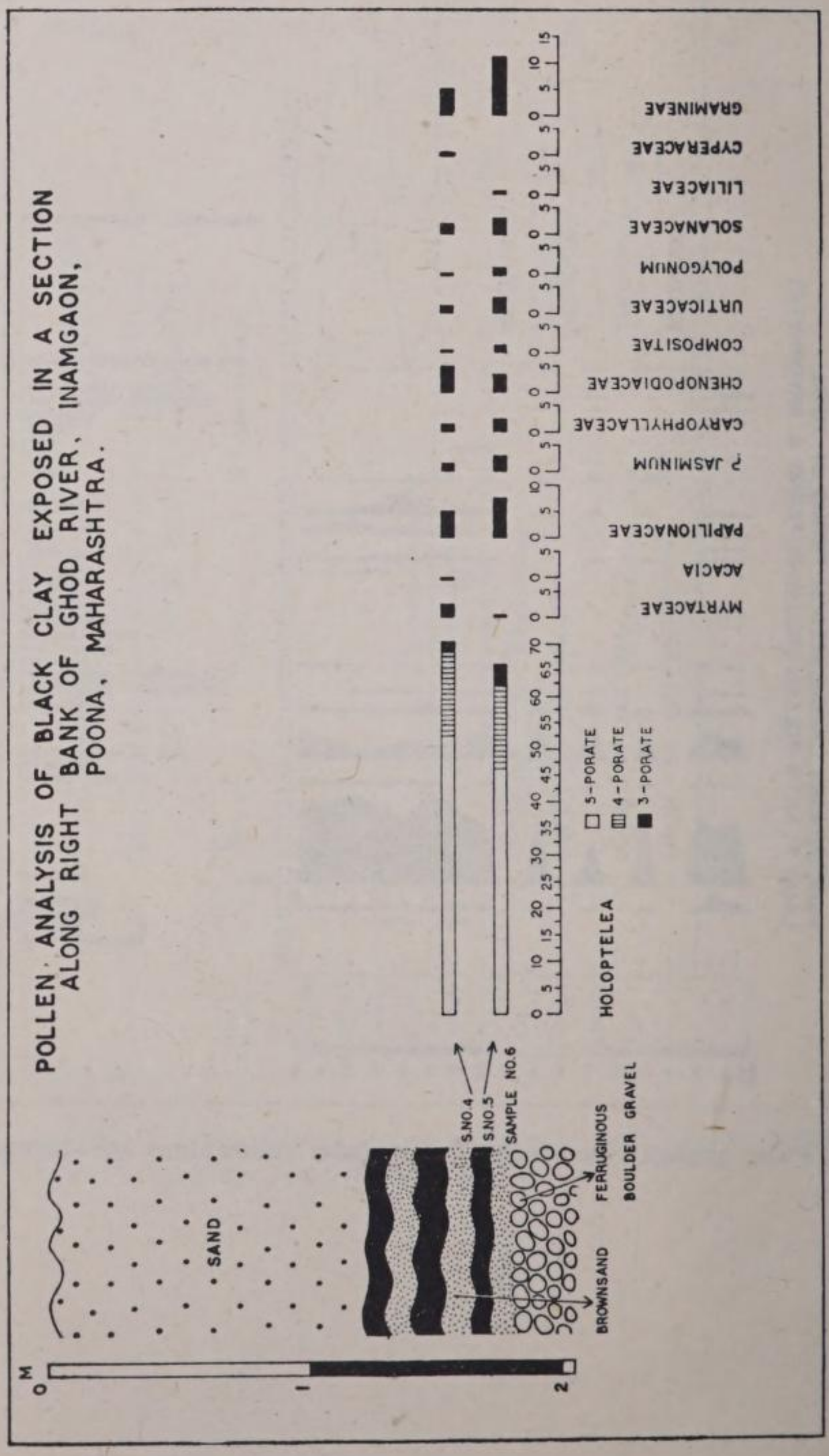
The evidence from microforams in the Nal Lake profile reveals three major episodes of marine incursion, the first between 5.50 and 6 m before 7000 B.P., the second between 2.60 and 4.50 m dated to 4000-6000 B.P. corresponding with eustatic rise of sea level, and the third at the extreme top surface of the lake dated to 160 B.P. and this corresponds with large-scale marine inundation caused by the June



Text-fig. 8. Pollen diagram from Nalsarovar Gujarat. Biostratigraphy not indicated (after Vishnu-Mittre and Sharma 1975c).



Text-fig. 9. Pollen diagram from Malvan, Gujarat (after Vishnu-Mittre and Sharma 1975a).



Text-fig. 10. Pollen spectra from buried soils from Ghod river Inamgaon, Maharashtra (after Vishnu-Mittre and Gupta 1975)

1819 earthquake in Kutch which was responsible for sinking of Sindri Fort and rise of Allahabund. It is interesting to discover that this lake was not affected by marine incursion from 2550 B.P. until 160 years ago. On the other hand, the oxbow lake at Malvan was continuously influenced by marine incursion but for a brief period of recession when the riverain dry deciduous forest had declined.

B. THE ENVIRONMENT OF EARLY FOOD PRODUCTION

Howsoever disjunct and patchy the information of botanical environment in northwestern and western India is available at the present, it nevertheless provides some valuable information on environment for early man to build up man-plant relationship. The positive evidences of the pre-Neolithic man/plant relationship, however, are lacking at the moment and we are indeed ignorant of the way early man who was a food gatherer had utilised wild plant life. We can however presume that early man had supplemented his highly proteinaceous animal diet with products of wild plant life such as tubers, leaves, fruits, etc., of which we have no palaeobotanical record.

It would appear as the evidence has it that man in ancient India was acquainted with fire fairly early in history. Positive evidences are known from Sarai Nahar Rai (U.P.) where charred bones are dated to 10,350 B.P. (TF-1104); Bhimbetka, Bhopal, where the charcoal fragments occur in cave sediments dated to 6000 B.P. (vide PRL-17), and from Bagor in Rajasthan where charred bones are dated to 6250 B.P. (TF-786). The evidence of fire known from pollen analyses from the beginning of Holocene or around in Kumaon* and Rajasthan (Vishnu-Mittre *et al.*, 1967; Singh *et al.*, 1974) lacks the convincing proof that these were not natural fires. Evidence indeed is wanting if these fires were used as a means of changing soil aridity, or to induce fresh growth of palatable grasses in the desert or to drive game or to effect a sophisticated system of land-use.

The evidence of fire associated with shifts in pollen curves, appearance of culture pollen and large-sized grass pollen believed to be of cereals had convinced us of the early methods of farming – the slash and burn practice (Vishnu-Mittre, *et al.*, 1967; Vishnu-Mittre,

*The Kumaon pollen sequence is now believed tentatively to date from the beginning of Holocene if not earlier in analogy with the C 14 dates of Toshmaidan pollen profile discussed in the text.

1974d). This event may now perhaps belong to early Holocene or earlier as discussed above (Cf. footnote below). In that event it may not be indicative of the earliest record of farming for the Neolithic in India had commenced much later. That large-sized* grass pollen in India and elsewhere too cannot be distinguished from the large-sized pollen of wild and cultivated grasses has now been demonstrated (Vishnu-Mittre, 1973b) and further its occurrence is also recorded from the Full Glacial and late Weichselian Cf. footnote below. Consequently, the large-sized grass pollen might belong to natural hybrids among wild grasses thus minimising its significance for past agriculture (Vishnu-Mittre, *op. cit.*). The culture pollen would appear during vegetation succession induced by opening out of the forest by natural means (land slips, wind, snow, etc.) or by man. We should not overlook the fact that forest clearance could have been caused by herbivores resulting in soil disturbances providing habitat for the culture plants. They could as well have been induced by pollarding and lopping or during creation of pastures for the semi-domesticated animals brought under control by early man.

With the assured Neolithic context some of these clearances may pass off as events of human influence upon vegetation to provide land for the purpose of farming and settlement. The forest clearance in Haigam pollen diagram from the Kashmir Valley dated to the Neolithic on conservative estimate will now lose its significance for earliest farming for its Neolithic context may not most likely be supported by C 14 in view of absolute dates available for Toshmaidan profile. The first event of food production by early man rests upon undisputed date of the Neolithic in India which has hitherto been found to be around 3000 B.C. The evidences are now forthcoming that the Neolithic in India is perhaps older by some millennia than 3000 B.C. Such indications were suggested in comments on radiocarbon dates of Chirand by me (Vishnu-Mittre, 1974a). Recently the Chalcolithic overlying the Neolithic at Koldihwah in district Partapgarh has been dated to 4500 B.C. (PRL-101). Obviously here the Neolithic is much anterior to this date. The proper dating of the Neolithic in India is important to determine the factors that might have led early man towards food production.

*Large-sized grass pollen above 50 μ are known in Kathmandu profiles dated from 17,270 ± 280 B.P. and their number increases in the late Weichselian (Vishnu-Mittre and Sharma, 1975b).

An important requisite for the early man/plant relationship in regard particularly to food production lies in the availability to early man of wild ancestors of modern crops near settlement sites and in the factors responsible for the development of early man's contact with them. The progenitors of rice are known to occur wild in marshes and riverain habitats in the Ganga plains and in eastern India. *Aegilops tauschii*, a progenitor of wheat, occurs in Baluchistan, Hazara, and Kashmir from 1500 m to 2600 m and *Hordeum spontaneum*, a progenitor of barley, occurs in Baluchistan and north-western India. The most suitable environs preferred by man for habitation were watery sheets of water, river banks, etc. It is here that he happened to be in direct contact with the ancestors of modern rice. It is obvious that initially he subsisted on wild rice. The Neolithic potsherds at Koldihwah have rice imprints belonging to wild rice as far as we have been able to determine. From the distribution of its wild ancestors it is obvious that rice was domesticated by early man in the Ganga plains and its cultivation in the Himalaya up to 2000 m is subsequent to the event of its domestication. Both its domestication and diffusion must have involved considerable human movements and cultural interactions.

In spite of the occurrence howsoever sparingly of progenitors of both wheat and barley in north-western India we still continue to be ignorant of the early steps towards domestication of these two cereals on the Indian sub-continent. The records of highly evolved cultivars in the Neolithic-Chalcolithic cultures with which the Indian history of cultivated plants begins and the belated opening of Neolithic in India compel us to believe that for both the import of these cereals and the import of the art of their cultivation we have perhaps been at the receiving end. This distressing fact indeed calls for intensive research to settle the issue once and for all whether any early indigenous steps had involved in the development of our agriculture or else soon after emergence from the habit of food gathering, early man in India was gifted with the highly evolved cultivars and their art of cultivation from agencies outside India. We are certain that our knowledge of the history of minor crops such as Jobs' Tears (*Coix lacryma jobi*), *Digitiaria cruciata* var. *esculenta*, *Paspalum sacrobiculatum*, *Echinochloa frumentacea*, *Digitaria sanguinalis* subsp. *aegyptaica* var. *frumentaceae* which occur wild and also are cultivated in the Himalaya within 2600 m above sea level and some in remote inaccessible areas is likely to provide useful information on the early

steps towards food production. Some of the missing links may also be discovered in some of the wild grasses such as *Brachiara deflexa*, *Echinochloa crusgalli*, *E. colonum*, *Dactylolectinium aegyptaicum*, *Setaria glauca* and several others which occur wild within 2700 m above sea level and constitute today poor man's grains in times of famine. These are largely the fodder grasses and must have been used by cattle and other animals domesticated by early man. These are all the more reasons to believe that early man, living in an environment of domesticated animals and fodder grasses, was led to seek food in the grains of the fodder grasses which grew wild then. And subsequently he adopted some of them as his own food crops raising them by the primitive methods.

The hitherto known Neolithic in India dated to around 3000 B.C. corresponds with the sub-Boreal period during which maximum warm and dry climate had prevailed in most parts of the world. North-west India does not seem to be an exception. In Rajasthan too the climate was warm and with violent dust storms and high speed winds rather than wet as interpreted by Singh (Singh *et al.*, 1974). The Neolithic man in the Kashmir Valley was still at the food gathering stage and all the seeds gathered by the Neolithic Kashmiris belong to forage plants (Vishnu-Mittre, 1974d) but the Neolithic-Chalcolithic man in western India and in the Ganga Valley was familiar with wheat, barley, and millets (Vishnu-Mittre, *op. cit.*) and the evidence of their actual cultivation is now known as at Kalibangan (Lal, 1970-71). The environment as known today of wheats indentified from the archaeological sites comprised low fertility soils with little precipitation and these wheats were drought-resistant and tolerant of soil salinity. Barley grew in more saline and drier areas than for wheat and the millets in dry arid areas. Barley and wheat are crops of hard conditions of both soil and climate. Here is an interesting correlation between the inference of environment from pollen and the archaeobotanical data suggesting that the dry arid climate is probably conducive to food production.

There is ample evidence of the exploitation of botanical environment by the Neolithic man and his successors in the identity of charcoals and wood, etc., from the archaeological sites (Vishnu-Mittre, 1974c). Most plants identified still occur in the vicinities of the sites, their remains are discovered from, suggesting that the botanical environment has remained the same but for its degradation under the ever-increasing human exploitation. Some charcoals have been found

to belong to plant species occurring in different climatic regimes situated distantly suggesting the Neolithic and post-Neolithic man's rambles far and wide in search for economically exploitable natural wealth which paved the way for the development of socio-economic contacts.

SUMMARY AND CONCLUSION

In spite of more palaeobotanical information available today from North-west India, the information continues to be patchy and discontinuous with large gaps for which no information is available. There is need to build up several pollen diagrams from each region and to discover more megafossil evidence for precise environmental inference. The problems posed by the interplay of pollen grains more particularly in regard to their local and extra-local status require understanding and resolution because the face value interpretations would lead us nowhere. The absence of seeds and fruits in the sediments serve a note of caution against over-all dependence upon pollen grains. There is also considerable need to correlate judiciously the micro and megafossil evidences for palaeoecological inference. The only recourse is intensive attempts towards identification of pollen grains and megafossils to the modern plant species and acquisition of sound knowledge of their climatic requirements so that palaeoecological inference is more reliably based.

It must be admitted that the implementiferous sediments whenever examined have been found without palaeobotanical more particularly palynological evidence. The reconstructed environment of early man from non-implementiferous lake and swamp sediments poses a problem so far as its correlation with human cultures is concerned. The reference of palaeobotanical information to Miocene, Pliocene or to Lower to Upper Siwaliks or to Glacial, Interglacial and Holocene on stratigraphical and palaeobotanical grounds provides a tentative basis for such a correlation with the cultures referred to or known during such periods of time. The radiocarbon dates indeed provide supporting evidence from the last glacial onwards. It is thus obvious that until the beginning of the Holocene, Palaeolithic cultures had dominated the scene, and the Mesolithic during the early part of the Holocene followed by the Neolithic and Chalcolithic, etc. Evidences are forthcoming that the Neolithic in India perhaps began much earlier than proven so far. In view of insufficiency of palaeobotanical

evidence and the inadequacy of knowledge regarding their identity and proper evaluation for environmental inference and the lack of ecological information of the corresponding modern forms, a broad outline of environmental changes inferred from plant remains from Miocene to early historical has only become possible.

The oceanic tropical wet climate which characterised the entire north-western and western India during the Eocene times (Vishnu-Mittre, 1969) continued during the Miocene times also. Though it was less oceanic than before, the temperatures were still equable and the montane topography which had built up by this time had supported tropical semievergreen forest with good admixture of tropical deciduous elements. The forests were more or less closed and the land was studded with marshy and swampy areas. No evidence or vast stretches of open ground vegetation has been found Mountain building had caused sufficient rise in certain areas located distantly to have induced the immigration of conifers.

The climate became continental and moist during the mid-Miocene times. The deciduous elements in the forest had increased which was responsible for the creation of stretches of open ground vegetation and which had continued to remain under intense grazing influence by herbivores. The immigration of conifers had increased. The gradual worsening of climate reached climactic stage in the Boulder Conglomerate Zone when the glacial conditions were established.

The early Pleistocene climatic events in the Kashmir Valley were much the same where moist temperate oak woods comprised the botanical environment prior to the First Cool Oscillation. The moist Blue Pine woods were established thereafter until the Second Cool Oscillation had replaced them by moist conifer-mixed-oak woods. The rise of Pir Panjal mountain during second glaciation has been largely responsible for a drastic change in the climate of the valley from moist to dry by serving as an almost impenetrable barrier to the monsoons.

The late-Glacial opened up with open ground vegetation and conifers and/or mixed broad-leaves woods with cooler climate than at present and in the Kashmir Valley particularly cooler and drier climate had prevailed. The succession in botanical environment from the last glaciation to the early historical in the rest of the Himalaya was largely governed by the monsoon climate. The climate colder than the present had occurred in the subtropical region during the last glacial and early Holocene. The occurrence of thermophilous trees together with open ground vegetation is perhaps indicative of the

absence of arctic-subarctic climate during the Full Glacial and late Weichselian times. The oak-mixed conifer woods were open in the Kashmir Valley which during mid-Holocene times suggest the continuation of drier climate but the dense oak-mixed conifer woods in the rest of the Himalaya suggest the establishment of present-day climatic conditions. Their subsequent change-over to conifer woods was largely governed by human influence which was responsible for the decline of oak woods in the Kashmir Valley and Himachal Pradesh.

A climatic gradient such as seen at the present characterised the Holocene climate in the northern and north-eastern part of the Rajasthan desert. And this gradient fluctuated between 150 and 400 mm annual precipitation and dry period extending over 9-11 months and possibly the mean temperature of the coldest month was around 15°C or less. Between 5000 and 3000 B.P. the environment in the desert was characterised by high velocity winds and increased intensity of dust storms when appreciable warmth and aridity were attained. The salt content in the lakes which were moderately salty to start with gradually increased and the lakes had risen between 5000 and 6000 B.P. The sand dune formation activity had intensified during the hypsithermal and had encroached upon the eastern parts of the Rajasthan desert.

In the coastal regions of Gujarat there occurred an environment of dry deciduous savannah riverain forest possibly during the early and mid part of Holocene. The dry deciduous riverain forest declined about 4000 years B.P. giving rise to arid steppe conditions. During the dry deciduous forest phase between 6000 and 4000 B.P., the eustatic rise of sea level had inundated the coastal areas of Gujarat and as far inland as Nalsarovar 40 km N of Ahmedabad. Evidence has also been found of the marine inundation of the lake prior to 7000 years B.P. After the eustatic rise in sea level the marine incursions were confined only to the coastal Gujarat but failed to influence the Nalsarovar until 160 B.P. corresponding with the historical inundation caused by the earthquake in 1819.

Broadly interpreted, the climatic evolution in north-western and western India from the mid-Miocene to the early historical comprised a progressive drying up of climate from the Eocene-Miocene times. The temperature changed from equable to continental and from warm to cool. A considerable reduction in precipitation is also observed from a wet climate to the present-day dry one and in certain parts in

western India to dry arid climate. The mountain building, the glacial episodes and lastly the hand of man have all contributed in bringing about the progressive decline of climate which was once uniformly wet throughout north-western and western India.

The insufficiency of palaeobotanical data and too few radiocarbon dates as at hand at the moment do not permit large-scale correlations in climatic fluctuations across this vast region.

The environment conducive to food gathering had existed for a fairly long span of time, though positive evidence of the kind of botanical wealth exploited for the purpose remains unknown. Fire was known to the early peoples since the beginning of Holocene though positive evidences are lacking of the disturbance of natural vegetation through fire and induced by man. Events or short-term disturbance of natural forests have been discovered in the Himalayan pollen diagrams particularly in the Kashmir Valley. It remains to be established if these were caused by early man or by herbivores. If caused deliberately by man we indeed fail to recognise the object behind them. Cereal cultivation earlier interpreted can no longer be pressed as the pollen of wild and cultivated grasses in India has been found indistinguishable.

Against the transitional stages from the habit of food gathering to food production with the opening of the Neolithic in India, the evidences at hand reveal either the persistence of food gathering or cultivation or both. The cultivation by Neolithic Indians of highly advanced cultivars for most of which history of domestication and evolution is known from elsewhere preceding Indian Neolithic by several millenia makes a strong case for the import of such cultivars as wheat, barley, and millets from western Asia and Africa. Perhaps the art of their cultivation was also imported from outside India.

To know the transitional stages we need build up our knowledge of the history of minor crops and the ethnobotanical history of quite a few wild grasses which constitute today, poor man's grains in times of adversity. The early man in India may have commenced with these to lay the foundation of food crops. These are largely the fodder grasses. Living in an environment of fodder grasses and domesticated herbivores it is quite plausible that the early man was led towards their selection and adoption as food plants and thus paved the way for their incipient cultivation. The riverain environment chosen for his settlement sites subsequently brought him in close contact with the wild rices growing in marshes along the rivers. These events must have

taken place several millennia prior to the too recent date 3000 B.C. for the opening of Neolithic in India which was indeed much older than hitherto dated by radiocarbon.

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TABLE 1

THE KATHMANDU VALLEY

The two sites are about 5 miles apart as the crow flies and about 1338 m above sea level. Based upon unpublished data by Vishnu-Mittre and Sharma 1975b.

	MANIHARA		*KALIMATTI*
11,830 ± 120 (9850 B.C.)	*Open ground vegetation* dominated by grasses (with Oak-Alder-Birch woods)		
12,930 ± 170 (10,980 B.C.)	*Open ground vegetation* dominated by grasses (with Oak-Birch woods)		
13,930 ± 360 (11,980 B.C.)	*Open ground vegetation* dominated by grasses (with Oak woods)	13,710 ± 170 (11,760 B.C.)	No Pollen
			Open ground vegetation dominated by grasses, chenopods (with Pine-Oak-Birch woods)
	Open ground vegetation dominated by grasses and *Artemisia* (with Oak wood)		*Open ground vegetation* dominated by grasses, chenopods (with Oak-Pine-Birch woods)

(*Contd.*)

TABLE I (*Contd.*)

Open ground vegetation with grasses, *Artemisia* and chenopods (with Oak-Pine-woods)	15,320 ± 230 (13,370 B.C.)	No Pollen
		Open ground vegetation dominated by grasses, *Artemisia* chenopods (with Oak-Pine woods)
	17,270 ± 280 (15,320 B.C.)	*Open ground vegetation* with grasses and chenopods and *Abies*, Spruce *Birch (Pine-Oak) woods* *Open Abies-Birch (Oak-Pine) woods* *Open Abies-Pine (Oak) woods* *Open ground-vegetation* dominated by grasses and chenopods with *Abies* (Pine-Oak woods

Remarks: The climatic sequence of the botanical environment during the Weicheselian and late Weicheselian is being worked out and will be published shortly. The stadial and interstadial fluctuations in the periglacial environment are becoming apparent.

TABLE II

THE KASHMIR VALLEY

Based upon data published by Singh 1963; Vishnu-Mittre and Sharma 1966.

TOSHMAIDAN MEADOW 3120 m.	*HAIGAM LAKE* 1700 m.
Abies-Blue Pine-Birch Forest with grass and *Artemisia*	*Open Blue Pine-Abies-Birch Forest*
Blue Pine-Birch-Abies Forest with *Artemisia*, Grasses and chenopods	*Open (Oak) Birch-mixed conifer Forest*
Open Birch-Blue Pine (Oak-Elm) Forest with *Artemisia* and Grasses	Open *Birch-Abies-Spruce-Alder-Elm Forest* with grasses, *Artemisia and chenopods.*
Open Blue Pine-Birch (Quercus, Alnus) Forest with Chenopodiaceae, *Artemisia*	*Open (Oak) Birch-Walnut-Alder-Spruce Forest* with *Carpinus* and *Corylus* with *Artemisia*, Compositae and Chenopods
Open Blue Pine-Birch Abies, Spruce (Deodar-oak) forest with *Ephedra,* Chenopodiaceae, *Artemisia and Grasses*	*Open Spruce-mixed conifer-(Oak)-deciduous* (Elm, Walnut) forest
Open Blue Pine-Birch (Deodar-oaks)	*Open Fir-Spruce-deodar, Blue Pine* forest with *Taxus*, Elm and Ash
Open Ground vegetation (Blue Pine-Deodar-oaks) with Compositae and Gentrospurmae	*Open Ground vegetation* with grasses, chenopods, *Artemisia* and deciduous Ash-Elm (Oak-Alder) forest in sheltered localities.

Remarks: The two pollen diagrams seem to present ± synchronous vegetational development. The fresh pollen diagram from Toshmaidan with the dates now available will be shortly published by Gurdip Singh (pers. comm.). The absolute dates now available replace the dating attempted earlier by other means.

TABLE III

HIMACHAL PRADESH

Based upon data published by Sharma and Singh 1974a, b

KHAJIAR

1950 m above sea level

1250 ± 60 B.P.	Deodar-Oak woods	
1800 ± 55 B.P.	Oak-Elm-Walnut woods	Temporary opening
1830 ± 50 B.P.	*Artemisia*, Chenopods, grasses	of forest
	Oak woods with Deodar, Cupressus, (*Abies*)	
	Oak woods with Taxus, (*Larix*, *Abies*)	

REWALSAR

	Open Ground vegetation (with chirpine)
530 ± 55	Chirpine woods
1410 ± B.P.	Decline of oak woods
	Oak-*Goryplus* woods
	Oak woods

TABLE IV

KUMAON HIMALAYAS, U.P.

Naukuchhiya Tal

From data published by Vishnu-Mittre *et al.* 1967

Open oak mixed Chirpine woods with Walnut, Elm (*Abies*)

Oak mixed Chirpine woods with (Celtis), Salix, Carpinus (Morus)

Oak mixed Chirpine woods with (Celtis), Alnus, Salix (Morus)
Rosaceae, Urticaceae and lot of shrubs

Charcoal *Chirpine mixed oak woods with salix and Corylus*
with good grass
Chirpine woods

Remarks: The detailed pollen stratigraphy of pollen diagram from this lake has not been published yet.

TABLE V

RAJASTHAN DESERT

Based upon data published by Singh *et al.* 1974

Succession in Desert plant Societies				*Exotic pollen*	*Temperature and Precipitation*	*High speed winds and dust storms*	*Sand dune formation activity*
Years B.P.	*LUNKARANSAR*	*DIDWANA*	*SAMBHAR*		Continuation of high summer temperatures	moderate	
	Calligonum-capparis-Aerva Soc.						
3000	*Calligonum-Ephedra-Maytenus* Soc.	*Capparis-Ephedra-Calligonum-Maytenus-Acacia* Soc.	*Capparis-Ephedra-Prosopis-Acacia* Soc.	Increased values of *Pinus*, *Sygygium*	Maximum dry and warm (Summer temp. high)	High	Intense sand dune formation activity
	Calligonum, Maytenus, Ephedra-Ziziphus-Prospopis Soc.	*Capparis-Calligonum, Ephedra-Prosops-Ziziphus* Soc.	*Capparis-Acacia-Prosopis* Soc.				
5000	*Calligonum-Ziziphus-Maytenus* Soc.	*Maytenus-Calligonum, Ephedra* Soc.					

	Maytenus-Capparis-Ephedra-Prosopis Soc.	*Maytenus Mimosa Capparis-Ephedra-Prosopis* Soc.	Progressively drying and warming with increase aeolian activity	moderate	Advance of sand dune activity towards the east of the desert.
Maytenus-Ephedra-Capparis Calligonum Soc.	*Maytenus-Ephedra* Soc.	*Maytenus-Mimosa-Capparis-Ephedra* Soc.			
10,000 *Calligonum-Ephedra-Capparis* Soc.		*Mimosa-Ephedra-Maytenus-Acacia* Soc.	Summer temperatures comparatively lower		

Remarks: The vegetational succession from the undated Pushkar lake pollen diagram is not included here. The sand dune activity advanced here when the area was populated by the dry *Anogeissus* forest and the pollen diagram reveals the recovery of the *Anogeissus* forest in the immediate past when the dune formation activity had ceased. The plant societies are recognised here from the percentage frequencies of their pollen in the pollen diagrams, as done in the previous tables. Obviously the reconstruction of these societies is limited by the differential production and preservation of their pollen of which our knowledge is poor at the present.

Stratigraphy and Palaeoecology of Quaternary Sediments of North West Himalaya, India

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INTRODUCTION

In India, the Quaternary sediments have a very wide geographical distribution in both the Peninsular and Extra-Peninsular regions. In the latter region, the sediments belonging to this geological period are found along the entire length of the Himalaya from Kashmir in the north-west to Assam in the south-east for about 2400 km. The ideal sections for the study of Quaternary sediments are the Upper Śivaliks of Lesser Himalaya, Karewa Formation of Kashmir Valley, and the terrace deposits exposed in different parts of the Himalaya. In addition, unconsolidated deposits of alluvial, illuvial, and glacial origin are found all over the Himalaya. The remnants of terrace deposits can be observed along the sides of the valleys whereas the more recent gravel and boulder beds occur along the present-day rivers. The large illuvial screes, at their maximum angle of repose have developed on the steeper slopes and now cover extensive areas. Numerous terminal and lateral moraines, and the glacial lake deposits are found scattered throughout the region although, at the present time, glacial deposition is confined to the higher altitudes. These surficial deposits were laid down during different geological times after the main uplift of the Himalaya, i.e., commencement of Middle Miocene Epoch. In addition, different parts of the Himalaya experienced alluviation due to the blockage of rivers by landslide debris.

The lower horizons of the Quaternary Period (Pleistocene sediments) can be separated from the conformably and gradationally underlying Pliocene beds only in certain parts of the Himalaya. Pilgrim (1944) and some other workers included the Pinjor Formation (middle Upper Śivaliks) in the Pliocene. The Ist Interglacial was a longer period representing the deposition of many thousand metres of Upper Śivalik sediments followed by a period of Śivalik orogeny and peneplanation. According to Sahni and Khan (1964) the first appearance of *Leptobos* and *Archidiskodon* in India marks the end of the Pliocene rather than the beginning of Pleistocene since these genera are indigenous to India or to some area nearby.

Wadia (1951) supported Pilgrim's view and believed that the glaciation began much earlier in Europe than in Asia. According to him the beginning of Pleistocene is not an important datum line as it is in the northern latitudes.

Pilgrim (1944) compared Pinjore fauna with that of Red Crag of East Anglia which is considered equivalent of Villafranchian and opined that Villafranchian is definitely pre-glacial. He supported his argument on the discovery of glacial boulder bed at Bain lying below the beds containing *Elephas planifrons*, *E. hysudricus*, *Equus cautleyi* and this led him to place the beginning of Pleistocene at the base of the Bain Boulder Bed and above the Pinjor Formation. The Bain Boulder Bed and the overlying Upper Boulder Bed were correlated by him with the Günz and Mindel Glacial Stages of Alps. The International Geological Congress at its session held in Great Britain in 1948 decided that the boundary between the Pliocene and Pleistocene be placed at the base of Pinjor Formation. Sahni and Khan (1964) supported the decision of the International Geological Congress held in 1948 and suggested that the Boulder Conglomerate Formation of the Upper Śivalik Sub-Group corresponds to the 2nd Glaciation, thereby indicating that the Ist Interglacial deposit is missing in Śivalik succession. They considered the Tatrot Formation to be of Upper Pliocene age and the Pinjor to be of Lower Pleistocene age. These workers placed the Plio-Pleistocene boundary at the base of the Pinjor Formation on the basis of the first incoming of *Equus*, *Hypselephas*, *Rhinoceros*, and *Bubalus* in this formation

The presence of *Equus*, *Rhinoceros*, *Camelus*, *Bubalus*, etc., indicates Pleistocene age for the Pinjor Formation and the absence of *Proamphibos* confirms this contention. The presence of the latter form in the Tatrot Formation is suggestive of Pliocene age. In Kashmir, the

Lower Karewas are considered to be of Upper Miocene to Pliocene age and these are followed by the Upper Karewas of Pleistocene age.

The Pleistocene rocks in parts of the Lesser Himalaya of north-western India are represented by the Pinjor and Boulder Conglomerate Formations of Upper Śivaliks and the overlying river terraces. The sediments belonging to Pleistocene Epoch are exposed in different parts of north-western India including east and north-east of Chandigarh (Pinjor, Moginand, Naraingarh, Saketi, Kala Tibba, etc.), Bilaspur (Chakrana, Bhapral, Lanjhata, Badaun, Mehrana, etc. – Prasad, 1971), Hoshiarpur, Hamirpur, Kangra, Jammu, etc. The various units of the Pleistocene succession have conformable relationship with one another with the exception of the Upper Boulder Conglomerate Formation which lies unconformably above the Lower Boulder Conglomerate Formation. The Boulder Conglomerate generally occurs at the points of emergence of large rivers and their main tributaries. The upper clay bands in the upper part of this succession are indistinguishable from the alluvial clay of Punjab plains and both these have conformable passage with one another.

The source of Upper Śivalik sediments was the medium to high grade metamorphics, granites and gneisses of the Central Himalaya. The presence of the fragments of basalts in the Upper Śivaliks is suggestive of emergence of trap (basalt) as the source rock during this period (Kharkwal, 1969; Chaudhri, 1972). Raju and Dehadrai (1962) have recorded the presence of complex heavy mineral suit consisting of hornblende, sillimanite and andalusite which distinguishes it from the underlying Middle Śivaliks. Chaudhri (1975) and Pandey (1975a) on the basis of sedimentological studies of Upper Śivaliks in parts of Himachal Pradesh and Uttar Pradesh respectively postulated that during their deposition fresh water fluvial to subaerial environments existed. These workers have also suggested proximity of the source rocks to the basin of deposition. Pandey (1975b) on the basis of shape analysis of quartz grains of Middle and Upper Śivalik sandstone in parts of Uttar Pradesh has suggested that these sediments were being deposited by the currents of moderate velocity.

The Upper Śivalik succession in the Jammu-Kangra-Hoshiarpur-Pinjor areas has yielded rich and varied fauna and this region appears to have been a favourite haunt for a highly diversified elephant population, as is evident from the profusion and wide distribution of their skeletal remains. Other fossils found within the Upper Sivaliks are referable to *Bubalus*, *Bos*, Hippopotamus, *Merycopotamus*, *Hemibos*,

Leptobos, Camelus, Hexaprotodon, Potamochoerus, Coelodonta, Equus, Sus, Cervus, Givalis, apes and numerous bones of chelonians.

During the deposition of Upper Śivalik sediments, wetter conditions prevailed and the climate became distinctly cold particularly during the upper part of the Upper Śivaliks. This is indicated by the extinction of a variety of mammalian forms. The return of the cold conditions appears to be quite rapid which perhaps did not allow the mammals to adapt to the new changed climatic conditions and caused their disappearance either due to their migration to other places or extinction.

LESSER HIMALAYAN ZONE

A. Upper Śivaliks

a. Pinjor Formation

This formation forms an intermediate horizon between the Tatrot Formation below and the Boulder Conglomerate Formation above. It is named after the Pinjor town near Kalka in Haryana. The base of this formation at several places is marked by a conglomeratic horizon. It consists of coarse grit, siltstone interbedded with grey to green pebbly sandstone, friable brown to pinkish and sometimes yellow and red clay and cemented conglomerates. The sandstone of Pinjor Formation is cross-bedded with truncation of laminae towards the top indicating normal order of superposition. The sandstone also bears structures like ripple marks, armoured mud balls, load casts, etc., which indicate shallow water conditions of deposition. The conglomeratic intercalations in the Pinjor Formation increase near the top.

The Pinjor Formation has a very wide geographical distribution and has yielded rich faunal and floral remains. Bhatia and Khosla (1967) carried out micropalaeontological investigations of the rocks of this formation and recorded the occurrence of ostracodes from near Chandigarh. Bhatia and Mathur (1971) also described a few molluscs from this formation. The presence of charophyta within this formation was recorded by Bhatia and Mathur (1970) and Tewari and Sharma (1972). Tewari and Sharma (1972) concluded that part of the Tatrot and Pinjor Formations of Panchkula-Moginand region yielding charophytic remains represent more or less lacustrine conditions without too much movement of matter. The occurrence of a form

comparable to *Tectochara diluviana* in their collection [*T. deluviana* is very well known from the Elaster-Salle-Interglacial (Mindel-Riss-Interglacial) of Hannover] from the lower part of Pinjor Formation is also suggestive of their being deposited in warmer Interglacial period of the Pleistocene.

The presence of a few cold-living spore-pollen genera in the Upper Śivaliks of north-west of Jawalamukhi (Nandi, 1975) is suggestive of the incoming of a distinctly colder climate. This cold climate was instrumental in the migration and/or death of the then surviving fauna.

Verma (1969) and Nanda (1973a, b) have described vertebrate fossils from the Pinjor Formation exposed in the Naraingarh area of Ambala District. The succession described by Sahni and Mathur (1964) around Moginand near Suketi as Middle Śivalik is in fact of Upper Śivalik (Tatrot and Pinjor Formations) and contains rich vertebrate fauna. Halstead and Nanda (1973) have recorded a sequence of eight cyclothemes from the lower part of the Pinjor Formation. According to them, the environment of deposition during this period was a flat flood plain across which large rivers meandered. The vertebrate fossils in this formation occur in bottom lag gravels, point bar sands and overbank silts.

The fauna from the Pinjor Formations includes the following:

Vertebrates: *Stegolophodon, Hypselephas, Pentalophodon, Stego don insignis, S. bombifrons, S. magnidens, S. katliensis, Archidiskodon, Equus sivalensis, Hipparion theobaldi, Elephas hysudricus, Dicoryphochoerus, Tetraconodon, Sivachoerus, Potamochoerus palaeindicus, Hippohyus, Sus, Hypohyus, Merycopotamus, Hippopotamus, Camelus, Dorcatherium, Hydaspitherium, Solenoportax, Leptobos falconeri, Hemibos acuticornis, Bubalus, Bison, Geoclemys sivalensis, Bucapra* cf. *daviesii, Gazella, Rhinoceros palaeindicus, Punjabitherium platyrhinus, Hexaprotodon sivalensis, Cameplus sivalensis, Sivatherium, Camelopardalis, Giraffa, Canis, Agriotherium, Mellivora, Lutra, Enhydriodon, Viverra, Hyaenictis, Crocuta, Megantereon, Panthera, Felis, Rhizomys, Nesokia, Hystrix, Papio, Semnopithecus, Simia, Procynocephalus pinjori, Sinictis.*

Ostracodes: *Limnocythere* sp., *Candona candida, C. lactes, Ilyodromus* sp., *Hemicypris pyxidate, Zonocypris costata, Cypridopsis*? cf. *C. striolata, Ilvocypris braychi, Darwinula* sp., *Stevensoni* sp.

Lamellibranchs: *Lamellidens lewis*, *L. jammuensis*, *L. proctori*, *Lamellidens* sp., *Indonaia bonneardi*, *Pisidium clarkeanum*, *Pisidium* sp., *P. nevillianum*, *P. sivalensis*.

Gastropods: *Melanoides tuberculata*, *Ferrissia* sp., *Gvraulus singularis*, *Viviparus bengalensis*, *V. dubiousus*, *Digoniostoms* sp., *Tricula* sp. cf. *T. montana*.

Plantae: *Charites indica*, *Tectochara pinjorica*, *T.* cf. *deluviana*.

The Pinjor Formation is characterised by the presence of *Archidiskodon*, *Equus*, and *Leptobos*. The environment of deposition of the Pinjor Formation is marked by a reduction of extensive backswamps as chelonian, crocodilian and *Hexaprotodon* remains associated with the Pinjor Formation are less than the underlying Tatrot Formation.

The fauna from the Pinjor Formation is suggestive of Upper Villafranchian age for it.

b. Boulder Conglomerate Formation

This formation constitutes the youngest unit of the Śivalik Group and consists essentially of large boulders which were derived from the rocks of earlier ages and subsequently got consolidated by infiltration of siliceous material. The formation is composed of subrounded to wellrounded pebbles, cobbles and boulders of cemented sandstone and occasionally limestone embedded in a clayey or sandy matrix. Occasional beds of grit, sandstone, siltstone, and clay also occur. The Boulder Conglomerate Formation has been divided into a lower and an upper division by earlier workers (Gill, 1951a; Sahni and Khan, 1964). The former division is considered to be poorly fossiliferous whereas the latter is unfossiliferous. Badam (1973) suggested that the Boulder Conglomerate Formation in the area north-east of Chandigarh is a single unit and cannot be divided into two parts as suggested by earlier workers. The upper division in fact comprises a part of river terrace. According to him, the Boulder Conglomerate Formation is unfossiliferous with uniform lithology. Bhatia (1970) suggested that the Boulder Conglomerate Formation (= Tawi Formation) is of fluvioglacial origin and its best exposures can be met with in Jammu region of north-western Himalaya.

The Boulder Conglomerate Formation marks the commencement

of a change in climatic conditions, i.e., the onset of a pluvial phase (equivalent of the Günz Glaciation) accompanied perhaps by gradual uplift. Because of this change the rapid extinction or migration of the vertebrate fauna took place.

Pilgrim (1913) recorded the presence of several vertebrate fossils from this formation. The recent investigations have revealed that this formation contains poor fauna in the form of isolated teeth and limb-bones.

It is generally believed that the Upper Boulder Conglomerate was laid down after the Śivalik Orogeny which resulted in the uplift of the Himalaya during early Middle Pleistocene as a consequence of which it attained the greatest height and glaciation or cold climate prevailed all over. This orogeny brought the Śivalik sedimentation to an end as a result of which came the sudden and widespread extinction of the Śivalik mammals. The folding during this period is largely restricted to the foredeep deposits south of the outer boundary fault of the autochthonous folded belt.

The discovery of direct evidence of Glaciation in the Bain Boulder Bed in N.W.F.P. (Morris, 1938) was fixed by clear faunal evidence to be 'slightly later than Pinjor'. According to Gill (1951b), the Śivalik Boulder Conglomerate is a heterogeneous formation containing boulders and pebbles ranging from Dhokpathan Formation of the Middle Śivaliks to the uppermost part of the Upper Śivaliks. As the vertebrate fossils in the Boulder Conglomerate Formation are rare and poorly preserved, it would be difficult to accept the views of Pilgrim (1944) for considering these beds to mark the base of the Pleistocene.

Recently, Parkash *et al.* (1975) have carried out the study of thickness of cross-bedding units of palaeocurrents as deduced from cross bedding foreset dip azimuths of the Śivaliks of Punjab, Haryana, and Himachal Pradesh. They observed a consistent southerly palaeocurrent direction in the Upper Śivaliks thereby suggesting that the Upper Śivaliks were probably deposited in a single continuous basin instead of two separate basins as suggested by Raju and Dehadrai (1962). Mehndiratta (1960a) correlated the Pinjor Formation with the Post-Günz and Boulder Conglomerate Formation with Mindel-Riss Interglacial Periods.

B. River Terraces, Choe Terraces, Glacial, Lacustrine and Alluvial Deposits

The foothill region of the Himalaya is composed of multicycle river

terraces, choe terraces (in parts), and alluviai fans which have resulted from the superimposition of climate changes and crustal movements. These terraces have been worked out on the basis of geomorphological studies carried out by several workers (Theobald, 1874; Mallet, 1875; Middlemiss, 1890; Cotter, 1940; Heim and Gansser, 1939; Sahni and Khan, 1964; Sen, 1955; Nakata, 1972; Mukerji, 1975; and many others).

The first record on the recognition of post-Śivalik deposits were made by Medlicott (1864) who observed that the boulder gravel deposit was accumulated in the sub-Himalayan zone of Western Himalaya whereas the finer deposits filled the marginal area of the ranges in the Indo-Gangetic Plains. The presence of large erratic blocks of gneisses at the base of Dhauladhar Range in the Kangra District (Himachal Pradesh) was explained as due to the glacial action. According to Medlicott (1864), these erratics were brought in their present position by floating ice. Theobald (1874) believed that this is due to the existence of a large glacier which at one time extended from the Dhauladhar Range across the Kangra Valley up to the Beas River. He postulated that nearly seven glaciers had descended in this region. Cotter (1940) accounted these erratics due to catastrophism. Sharma (1973) on the basis of a study of Quaternary landforms in the Dharamsala area of Kangra District has suggested that the boulders (or so-called erratics) are not good indicators of the Pleistocene ice limits at least in that area. According to him, the moraines which extend to approximately 1,020 m above the mean sea level indicate this to be the lowest limit of valley glaciation reached probably during the Lower Pleistocene. The study of till fabric suggests the deposition of sediments in general under free ice flow conditions. The field evidences are suggestive of the presence of only one glaciation. The period immediately after deglaciation was more humid and tectonically unstable resulting in the evolution of alluvial fans and fluvial terraces. The mud flows in this area are of recent age.

Nakata (1972) differentiated two major depositional surfaces along the foothills of Himalaya, i.e., the lowest red soil covered surface and the main surface without red soil just below the former. According to him, these two surfaces can be traced along the major streams into the mountain and are considered to be related to the major depositional phases caused by climatic changes during the glacial periods in the Himalaya. The regional differences in horizontal and vertical distribution of the geomorphic surfaces are related to differential crustal

movements (Nakata, 1972). This has been demonstrated to be universally valid throughout the Himalaya and related to glacial and interglacial periods, events, and epochs (Bose, 1961; de Terra, 1939; de Terra and Paterson, 1939; Kar, 1962; Lal, 1956; Mohapatra, 1966, 1967; Nakata, 1972; Sahni and Mohapatra, 1964; Sahni and Khan, 1964; Sen, 1971; and Sharma, 1973). There exists an impressive inventory of Himalayan Gravel terraces. The terraces of Ghaggar, Sutlej, Beas, Yamuna, Giri, Ramganga, Gandak, Arun, Tista, and Brahmaputra located near the water-gaps, gorges and re-entrants at the hill-foot plain-hill junction sites need to be studied in detail for the additional wealth of information they provide.

The presence of a large number of Stone Age artefacts has been recorded from various terraces exposed in the Beas Valley of Kangra District, Sirsa Valley of Pinjor-Nalagarh area, Markanda Valley around Saketi, and valleys of Ravi and Chenab in Jammu by various workers. Correlation of these terraces exposed in various areas is shown in Table 1.

The implementiferous terraces in the Beas Valley are best exposed along the Banganga river near Haripur-Guler in Kangra District. Mohapatra (1966) established the presence of seven terraces in this area. In his subsequent publication he grouped the upper two terraces as part of the Boulder Conglomerate and thus reducing the number of terraces to five (Mohapatra, 1973a). The villages of Guler and Haripur are situated on T_3 whereas Ror is located on T_4. Joshi (1973) has demarcated the presence of five terraces (T_1 to T_5) on the Banganga river on Guler side. In addition to the five main river terraces, he observed two to three subsidiary terraces, i.e., lying between T_1 and T_2, T_2 and T_3, and T_4 and T_5.

In the Sirsa Valley, Mohapatra (1973b) has worked out the presence of three terraces and two of these are implementiferous. On the basis of radio-carbon dating (C 14) of the elephant tusk found from the contact zone between the white clay deposit and a thick deposit of white calcareous sand near Har Raipur in Himachal Pradesh, Mohapatra (1967) has assigned a post-Glacial age ($4070 \pm 95/4190 \pm 95$) to T_2.

Terrace T_3 of Sirsa river has yielded the following Upper Pleistocene Gastropods near the village Kishanpura in Nalagarh (Bhatia and Mathur, 1971):

to the highly controversial theory of influx of nomads towards the well watered valleys during the period of intense desiccation resulting in a change from parasitic to productive life (Toynbee, 1934; Childe, 1952). In view of the commencement of desiccation in N.W. India right after the last glaciation, as the author has tried to show above, the possibility of such an influx without appreciable interval cannot be summarily rejected in the case of this region. It is true that "the food-producing revolution does not seem to have taken place in the deserts" as Butzer (1964: 436) has pointed out. But looking at the location of early food-producing settlements in the semi-desertic areas in the Middle East situated in the 8 to 24 inches rainfall zone one wonders whether this theory can be discarded altogether. The major part of N.W. Indian plains specially towards the south today receives almost the same amount of rainfall where the sparse vegetation had never grown beyond the limits of steppe. Neither proposing to validate the implication of this theory in connection with the problem of the origins of food production nor championing the arguments in favour of a standardised natural habitat as is seen in Western Asia because both face the threat of rejection when the new evidences for early food-production in S.E. Asia (Taiwan and Philippines) and North China become established, attention may be drawn to the situation of the arid plains of N.W. India with its oasis valleys close to the foothill areas which is somewhat similar to the northern part of the Fertile Crescent. If "from the very beginning, man could take up his abode on the levees or on the desert margins of the Near Eastern flood-plains" (Butzer, 1964: 463), there is no reason not to presume such events taking place on the plains of N.W. India. Being surrounded by a desiccated topography these valleys eventually must have attracted plant life and a few species of animals where man perforce had also to confine himself for a major part of his time. This close circuit of man, animal and vegetation, to our mind, holds the key to the solution of the problem of Late Quarternary lithic developments in N.W. India.

The absence of microliths in this region could have been one of the consequences arising out of this environmental confinement. Easy availability of game animals which were small sized herbivores within the limits of a small confined area must have provided no refuge for developing better skills in terms of new tool out-fit for hunting-chasing. In addition, there must have been for the time being plenty of other sources of diet like vegetable, fishes, etc., available in these oasis valleys to acquire which, little special skill or new types of implements

were necessary. Therefore, by and large at that time (till these natural food reserves were exhausted) the small flake-tools of Final Soan could effectively meet the immediate needs.

The second consequence of this confinement could have been that in the long run it gave rise to the necessary motivation for making efforts towards food-production. Exploiting the advantage arising out of the physical isolation of these valleys, man must have caused heavy damages to animal as well as to the vegetation by that impairing their natural growth and multiplication, the aftermath of which would have been felt in rapid dwindling of the natural food reserve. Adequate replenishment without human effort, as far as vegetation is concerned, could hardly come up naturally from the soil because of the peculiar morphology and composition of the *Khadar* and desiccation thereof as discussed above. Therefore, sooner than other places man in the region of N.W. India, felt the necessity to produce food, not much as consequences of accumulated techno-cultural knowledge but being goaded by peculiar local circumstances. This goes to explain the greater antiquity of the peasant village and Neolithic/Chalcolithic culture of this region vis-a-vis the Neolithic/Chalcolithic in other parts of India.

Due to rapidly deteriorating ecological condition the three alternatives suggested by W. Gordon East (1965) were probably adopted simultaneously by groups of men in N.W. India in different biotopes of the Early Holocene period. (1) Those who stayed where they were, had to modify their way of life in order to survive the hard conditions (*ibid.*: 49). It applies to the Sub-Himalayan *duns* where a polished stone celt culture succeeds the Final Soan. (2) Some "could emigrate in search of more familiar and congenial environments in the wake of the wild animals on which they depended for their food" (*ibid.*). This gave rise to a new way of living within the steppe-desert belt known as nomadism which means "cattle driving, or the movement of flocks and herds from place to place in search of scanty available pasture" (*ibid.*). Such pastures in the region of N.W. India being located at the fringe of the plains (where there were small patches of waterpools or lagoons of the marl-bed evidence) we find the stray remains of a microlithic culture with Neolithic bias at a few places in Sind, Baluchistan, and arid areas of Western Rajasthan.(3) The third alternative was thinking of a new kind of livelihood by means of cultivation and animal husbandry in which case man could explore the possibilities of the formerly neglected riverine lands (*ibid.*). We have

already discussed in detail the circumstances under which man, animal, and vegetation became localised in the *Khadar* areas which come under this alternative. The locations of early peasant villages in the flood-plains (Khadar) of small valleys situated in the foothill regions of Baluchistan, Sind, and N.W.F. Province indicate a preference for such places than the valleys of big rivers during the initial days of efforts for food-production. "Mixed farming for instance was practised very early in the valley of the Nile, the Euphrates and the Tigris yet the oldest sites where mixed farming, probably transhumance, can be affirmed are not situated near the banks of these great rivers, as has been believed previously, but rather on some of the adjacent plains and foothills" (Narr, 1956: 138). The veritable unhealthy swamps in the valleys of big rivers, like the Indus system, were probably a strong deterrant to human settlement till the beginning of the Protohistoric period as D.N. Wadia has rightly pointed out (Wadia, 1957).

Recent excavations of Sanghao Caves in N.W. Frontier Province of Pakistan throw interesting light on the problem of those isolated microlithic industries which are found on the plains bordering the foothills (Dani, 1964). Three periods of occupation of the cave contain a lithic industry which is mainly Levalloise-Mousterian in character with a few microlithic blades and cores appearing towards the end (Allchin, B & R., 1968). Although whether these microlithic can be typologically equated with those of the Upper Palaeolithic of West and Central Asia or with the Late Stone Age (Mesolithic) types of Peninsular India is a matter yet to be settled, there should be hardly any doubt that the Sanghao lithic complex contains in itself the evidence of an autochthonous growth of the microliths. These once invented could easily spread to certain areas on the plains nearby as tool out-fits of those nomads who chose to adopt the second alternative during the Late Quaternary desiccation as discussed above. But the very fact that the microlithic industries, despite this local origin did not greatly multiply in Punjab N.W.F. area further supports our point of view that the plains of the Punjab due to reasons of ecological peculiarities could provide little encouragement to Mesolithic way of life.

From quite a number of early peasant village sites bordering the north-western edge of the sub-continent stratigraphic evidence shows existence of a sort of mixed economy based on both semi-nomadic pastoralism and sedentary agriculture (Braidwood, 1961). Although

the continuance of the former even when man has learned to settle down may be explained as a matter of preferential group behaviour, the economic relevance of both the ways of life cannot be separately assessed at this rudimentary stage of cultural development when more often than not interraction of both was bound to take place where mutual adjustments were called for more as a matter of necessity than choice.

If viewed from this point most of the microlithic sites of Gujarat and Rajasthan with varying proportion of pottery and other allied traits of settled culture will no more pose problems. It could be that by about 5000 B.C. a new culture fully accustomed to sustain itself in arid circumstances had reached this area. This, the culture of the microlith using people, had its initial development in the western foothills and not in the local lithic industries (Palaeolithic) is suggested by the Sanghao evidence. As is natural in the arid areas, the culture was bound to be more pastoral than agricultural; rather nomadic at the initial stage. This is amply manifested through the preponderance of food-gathering type of microliths in Rajasthan area. But where the folks happened to strike suitable riverine lands quick techno-economic transformation towards food-production through cultivation (Neolithic) could be the logical outcome. This probably is the reason why in the region of N.W. India little distinction can be made between the Mesolithic and Early Neolithic. Here we have more evidence of quick diversification than of a slow transformation which could naturally appear as overlapping succession.

This Post-Pleistocene kaleidoscopic cultural pattern will appear less hypothetical if one carefully looks into the antecedents of the Hoabinhian, the Joman, and the early food-producing cultures in the Western Honan province of North China. Almost identical to our reconstruction these cultures in S.E. Asia and Northern China are independent developments in widely divergent ecological situations from local Upper Palaeolithic bases as active responses to the post-glacial environmental changes (Chang, 1970). Here is no Mesolithic transition.

CONCLUSION

The cultural growth in N.W. India during the Pleistocene has been traced through the various stages of the Soanian. Its distinctive features suggest that the contemporary conditions of the terrain had played a dominant role in giving shape to its basic character and later

pattern of progress. In this no one factor in the changing biotope can be considered primary.

With due regard to the local ecosystem and ethology it is probable that at the end of the Pleistocene dispersal of fauna had taken place causing thereby some movement of man. Three hypothetical techno-economic alternatives at this crucial point of cultural growth are suggested by the author. Primarily due to the absence of conditions for the growth of a Mesolithic culture a comparatively earlier beginning of food-producing economy can be visualised in this region. This, however, is not to suggest that N.W. India was the Garden of Edèn. Neither should it mean that food production had started in this region immediately at the end of the Pleistocene. The transition could have been through a stage when emphasis on hunting slowly shifted to vegetative planting of non-seed tropical tuber plants and incipient animal taming. Probably being too brief this stage left behind no durable evidence. Under these circumstances what could have been the course of human action from this time till late protohistoric period can be visualised in three phases of development.

Due to its peculiar geo-tectonic history and morpho-environmental isolation the Sub-Himalayan region could have emerged as an optimal zone where a symbiotic equilibrium between man and animal probably existed throughout the Pleistocene. During this period man did not live on the plains but was present in Thar region (Mohapatra, *et al.*, 1963).

First Phase: As consequences of changed environment during the Early Holocene man tried to expand the ecological range of those resources over which he had depended so long. Therefore, it became imperative to move out of the foothill *duns*. Descending on to the plains at the wake of post-glacial desiccation man could begin simultaneous exploitation of several different ecosystems. The equipment of those coming from the foothill *duns* of Himachal Pradesh consisted of small flake tools (Final Soan) and those coming from the Western foothills of Baluchistan and N.W.F. area were probably the users of microliths.

Bifurcation of population, adopting two different modes of living on the plains, i.e., pastoral nomadism for those who did not happen to strike congenial riverine lands and cultivation for those who did strike, seems to have taken place by about 5000 B.C. Those who were left behind in the *duns* developed the polished stone celt culture which is the only true Neolithic remain found in this region. Closely succeeding

the Final Soan (Palaeolithic) it symbolises the beginning of an effort towards incipient food production as far as the Sub-Himalayan zone is concerned (Mohapatra, 1974b).

Second Phase: Due to fast deteriorating ecology cultural innovations came to be accelerated. Food-producing areas gave rise to urban nucleus which expanded its girth in course of time to cover adjoining river valleys. Thus the foundation of the first civilization (Harappan) came to be laid originally at the north-western corner of the plains. Its expansion in fact was the second major enlargement of human settlement on the plains covering a much wider area than that during the first phase.

Third Phase: Further expansion of human settlement and exploitation of natural resources on the plains can be noticed during the early days of the Indo-Europeans (Aryans of the Rg Veda) in India. A critical appreciation of the culture and economy as gleaned from the Rg Veda and a comparison between the small ill-developed Early Grey-Ware sites of minor temporary village nature in this area and the larger well-diversified ones in the central Ganga-Yamuna doab do not suggest any great cultural consolidation of these people on the north-western plains. Due to progressive ecological deterioration, the old valley stations made arable by the Harappans through agro-based efforts could hardly hold a basically pastoral people for long. Across the Aravallis there was the promise of 'fresh fields and pastures new'.

The outline of cultural growth pattern thus drawn is no doubt hazy. Looking into the dimensions of the problem and the infant state of the research, the author's thesis can at best be regarded as a provocation to dialectic exercises.

> "Whatever be the fate of my arguments, any one who collects and groups a mass of evidence, and makes an attempt to turn it to account which may lead to something better, has, I think, a claim to be exempt from any very harsh criticism of mistakes and omissions. As the Knight says in the beginning of his Tale:
>
> I have, God wot, a largë feeld to ere;
> And wayke ben the oxen in my plough.
>
> Edward B. Tylor
> *Researches into the Early History of Mankind and the Development of Civilization*. London. 1878.

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Index

Acheulian culture, 123
Adial Chauntra, 15
Aegyptopithecus, 7
Aiyengar, N.K.N., 2
Akhnoor, 76
Allahabad, 22
Allahabund, 47
Allchin, Bridget, 118, 119, 127
Alluvial deposits, 72-6, 82-4, 87
American Museum of Natural History, 2
Anantnag, 78, 79
Anchar Lake, 84
Andamans, 24
Antecedent rivers, 103-5
Aravalli hills, 119, 130
Archaen, 13
Aryan culture, 121-2, 130
Ashton, E.H., 8
Asia, South East, 24, 113, 125, 128
Assam, 24, 25, 41, 113
Awantipur, 78
Awasthi, N., 42
Awasthi, P., 82

Babeh river, 87
Badam, G.L., 71, 82
Badgam, 78, 79
Baghdad, 41
Bagor (Rajasthan), 47, 118
Bain Boulder Bed, 67, 72
Baker, W.E., 1
Balu-Goloa (Himachal Pradesh), 24
Baluchistan, 14, 49, 126, 127
Bandyopadhyay, N.N., 21, 23.
Banganga river, 74
Banerjee, D., 21, 22, 23, 25
Bangla Desh, 24
Baraia area (Kutch), 42
Baramula, 79
Barley, 49, 50
Basoli, 76
Baspa river, 87
Bawan, 83
Beas Valley, 74, 76, 110
Belon River, 21
Bengal, 24, 25, 113
Bhakra-Nangal area Environment, 23, 24
Bhandari, L.L., 21
Bhangar land, 114, 115
Bhatia, S.B., 21, 25, 69, 74, 75, 79, 80, 81, 84, 101, 102, 115
Bhatia, T.R., 71
Bhatt, D.K., 82
Bhed Khad (Himachal Pradesh) Environment, 23
Bhimbetka (Bhopal), 47
Bhopal, 22, 47
Bijbihara, 78, 79
Bilaspur, 68
Bombay, 22
Boru, 78
Bose, S.G., 74
Botapathri, 78
Boulder Coglomerate Formation, 14, 15, 26, 67, 68, 69, 72, 74, 79, 83, 109
Quaternary sediments, 71-2
Bovids, 14
Braidwood, R.J., 127
Bramapithecus, 2, 3
British Museum of Natural History, 11
Brown, B., 2
Buckland, W., 1
Budha Pushkar, 118, 119
Burma, 24, 25
Burzahon village, 84
Butzer, K.W., 125

Camelids, 14
Carnivores, 14
Cautley, P.T., 1
Cercopithecus, 1
Chakgajram village, 75
Chandigarh, 24, 68, 69, 75
Chandra, P.R., 78, 82

Chang, K., 129
Chaomukh, 15
Chapman, V.J., 41
Charophytes, 25
Chatterjee, S.P., 14
Chaudhri, R.S., 68
Chenab valley, 74, 76, 110
Childe, V. Gordon, 125
China
  Culture, 125, 128
  Pleistoscene deposits, 7
Chĩnji deposits, 12
Choe terraces, 72-6, 99, 100-2, 105, 106
Chopra, S.R.K., 1, 4, 5, 6, 7, 66, 75
Clark, J.D., 123
Clift, W., 1
Climate, 52-3
Colbert, E.H., 2, 10
Conroy, G.C., 11
Corruccini, Robert S., 7
Cotter, C.A., 73
Cultivation, 47-50, 119, 128
Cultural growth, 107-33
  Holocene, 124-8
  Phases, 129-30
  Pleistocene, 109-12, 122-4
  Vis-a-vis environment, 120-2
Cynometra, 24

Dagshai beds, 110
Dainelli, G., 78, 82, 85, 86, 111
Dal lake, 84
Darind, 78
Dayal, R., 21, 24
Dehadrai, P.V., 68, 72
Desai, R.N., 26, 77
De Terra, H., 1, 15, 26, 27, 74, 76, 78, 79, 81, 82, 84, 85, 86, 109, 111, 114
Dharamsala, 73
Dhauladhar Range, 73
Dhokpatham deposits, 6, 12, 79, 109
Didwana, 35, 37
  Pollen diagram, 39
Dipterocarpus, 24, 25
Djebel, 123
Drainage network, 102-3
Drummond, J.H.J., 123
Dryopithecine fossils, 2, 11-12
Dryopithecus, 2, 3, 4, 6, 11
Durand, H.M., 1

Earthquake, 1819 (Kutch), 47, 53
East, W. Gordon, 126
East Africa, 9
Egypt, 121
Environment, 20-65
Equipds, 14
Ettel, P.C., 7
Europe, 12
  Miocene deposits, 9

Falconer, H., 1
Farooqi, I.A., 26, 27
Fayum Oligocene, 7
Ferishta, 1
Fire, Knowledge of, 47
Fissistigma Wallichii, 24
Food production, 107, 119, 128
  Environment, 47-51, 54
Foote, Robert Bruce, 15
Forest clearance, 48
Fossil hominoids, 1-2
Frayer, D.W., 7
French Institute, Pondicherry, 37

Ganderbal, 79
Ganeshpur, 83
Ganga plains, 49, 50
Gansser, A., 73
Garhwal, 24
Gaussen, H., 37
Geddes, Arthur, 115
Geological Survey of India, 2, 3, 26
Geomorphological components, 98-100
Ghaggar river, 105, 120
Ghod river, 43
  Pollen analysis, 46
Ghosh, A.K., 21, 25, 42
Ghosh, S.S., 21, 25, 42
Gigantopithecus, 6, 7, 8, 11, 12
Gill, W.D., 71, 72, 109
Giraffids, 14
Glacial, 72-6, 82-4, 96
Goldwin-Austen, H.H., 81, 82

Gogajipathri, 82
Gordon, D.H., 113
Goswamy, S.K., 82
Grasses, 48, 50, 54
Greenfield, L.O., 11
Gregory, W.K., 2, 3
Grinlinton, Mr., 83
Groves, C.P., 7
Gujarat, 117, 119, 128
  Environment, 42-7, 53
Guler village, 74
Guleria, J.S., 42
Gulmarg, 77, 78
Gupta, H.P., 22
Gupta, V.J., 4, 15, 66, 110
Guzder, S., 22

Haigam pollen diagram, 29
Halstead, L.B., 70
Hamirpur, 68
Hangrang valley, 84
Har Raipur (Himachal Pradesh), 74
Harappa, 121, 130
Hardwar, 24
Hari Temple, Haritalyangar, 8
Haripur village, 74
Haritalyangar, 3, 4, 12
Hawkes, J., 84
Hazara, 49
Heim, A., 73
Hellman, M., 2, 3
High cup-shaped basins, 105
Himachal Pradesh, 22, 33, 53
  Pollen analysis, 62
Himachal Pradesh University, 87
Himalayas, 13, 49
Himalayas, North-West
  Environment, 22-34
  Quaternary sediments, 66-97
Holocene developments, 112-13
Hominidae, 10, 11
Hooijer, 10
Hoshiarpur, 68
Human origins
  Palaeontological evidence, 1-19
Hutchinson, C.E., 78

Inamgao, 21, 43
Indraloris, 1
Indus river, 110, 120
International Geological Congress (1948), 67
Islamabad, 83
Isolated molar, 4, 5-6

Jain, J.P., 86
Jaldhaka, 111
Jammu, 15, 68, 76
Jolly, C.J., 7, 11
Joshi, R.V., 74, 75, 83, 108

Kaldihwah (U.P.), 48
Kalibangam, 50, 121
Kalimatti
  Pollen stratigraphy, 32
Kallar, 15
Kamru, 87
Kangra, 68
  Nagri beds, 4
Kar, N.R., 14, 74
Karewa formation, 13, 14-15, 26, 27-8, 33, 34, 37, 66, 68, 77, 78
  Fossil fishes, 82
  Mossuses, 81-2
  Ostracodes, 80-1
  Plant fossils, 82
  Quaternary sediments, 76-82
  Taxa, 81
  Vertebrates, 82
Kargil Basin
  Quaternary sediments, 84-6
Kashmir, 13, 15, 22, 48, 49, 50, 54
  Environment, 26, 33, 34, 52-3
  Ostracode fauna, 84
  Pollen analysis, 29, 32, 61
  Quaternary sediments, 84-6
  River terraces, etc., 82-4
Kathmandu valley, 29, 59-60
  Pollen analysis, 29, 30-1
Kaul, S., 4, 5, 6
Khadar land, 114, 115, 126, 127
Khan, E., 67, 71, 73, 74, 98, 101
Khanna, A.K., 21, 24
Kharkwal, A.D., 68
Khokhra (Himachal Pradesh), 24
Khosla, S.C., 69, 115

Khrew, 84
Khundian village, 24
Kiaser Tao, 86
Kinnaur
  Quaternary sediments, 87
Kishanpura village, 74
Koldihwah, 49
Krynine, P.D., 12
Kumaun, 14, 24, 49, 63
  Naukutchiyatan pollen diagram, 29
Kuppa, 87
Kurungus, 83
Kutch
  Environment, 42-7

Lacustrine deposits, 72-6
Ladakh
  Quaternary sediments, 84-6
Lahiri, H.M., 110, 111
Lakes, 115, 116
Lakhanpal, R.N., 21, 24, 42
Lakhanpur, 76
Lal, B.B., 50, 74
Lamayum, 84
Langhnaj, 118
Larix, 25
Latapora, 78
Leakey, L.S.B., 11
Learmonth, A.T.A., 115, 120
Lesser Himalayan Zone
  Quaternary sediments, 69-76
  River terraces, etc., 72-6
Levant, 121
Lewis, G.E., 1, 2, 3, 10
Liddarmarg, 82
Lidder valley, 79, 83, 84
Limnopithecus, 9
Litho zones, 26
Lolab valley, 79
Lothal (Gujarat), 121
Lotsum, 85
Lower Pleistocene, 15
Lunkaransar, 35, 37, 41
  Pollen diagram, 38
Lydekker, R., 1, 2, 4, 76, 79

Macacus, 1
Madras, 15
Mahabale, T.S., 42
Mahajan, D.R., 42
Maharashtra
  Environment, 42-7
Malakpur, 15
Mallet, F.R., 73
Malvan (Gujarat), 22, 43, 47
  Pollen diagram, 45
Man-plant relationship, 47-51
Mandibular fragment, 4, 5
Man's habitat, 98-106
Mansbal lake, 84
Markanda valley, 74, 75
Mastanpura, 110
Mathur, A.K., 21, 25, 69, 74, 75, 101, 112
Mathur, Kewal, 42
Mathur, L.P., 70
Mathur, Y.K., 42
Medhcott, H.B., 73
Megafossils, 20, 21, 24
Mehta, K.P., 82
Mesopotamia, 121
Mesuruer, 15
Microfossils, 20, 21
Middle East, 125
Middlemiss, C.S., 14, 73, 81, 82
Milletia, 24
Millets, 50
Mio-Pliocene, 12, 16
Mirgund, 78
Mirzapur, 22
Misra, V.N., 118
Moginand, 70
Mohand (Himachal Pradesh), 23, 24
Mohenjodaro, 121
Mohapatra, G.C., 74, 76, 83, 103, 104, 105, 107, 110, 113, 122, 123, 124, 129, 130
Morris, T.O., 72
Mossin, J.J., 104
Mugharet-es-Skuhl, 123
Mukerji, A.B., 73, 75, 98, 123
Mula Dam (Maharashtra), 42
Mulbekh, 85-6

Naera area (Kutch), 42
Nagam, 78

Nagin lake, 84
Nagla terrace, 75
Nagri deposits, 12
Nagrota, 76
Nahans deposits, 12
Naik, P.K.K., 82
Nakata, T., 73, 74, 75
Nalagarh, 110
Nalsarovar, 22, 42-3, 44, 53
Nanda, A.C., 70
Nandi, Bharati, 21, 23, 70
Narr, Carl J., 127
Naugam village, 80
Naukutchyatal pollen diagram, 29, 32
Nepal, 14, 15, 22
Nepal diagrams, 29-32
Nichahom, 78
Nilgiris, 42
Ningalnala, 82
North America, 13
North West Frontier Province, 127

Orissa, 113

Pahlgam, 83
Pakistan
  Potwar region, 12
Papio, 1
Pampur, 78, 79, 84
Pandey, B.K., 68
Pandey, J., 4
Parkash, B., 72
Pascoe, E.H., 111, 115, 117
Pashkyum, 85
Paterson, T.T., 1, 15, 26, 27, 74, 78. 79, 81, 82, 84, 109, 110, 123
Pattan, 78
Pilbeam, D.R., 2, 3, 4, 7, 10, 11
Pilgrim, G.E., 1, 67, 72, 79
Piliopithecus, 8-10, 12, 14
Pinjore formations, 14, 24, 25, 26, 67, 68, 109, 110
  Fauna, 70-1
  Quaternary sediments, 69-71
Pinus, 25
Pir Panjal, 29, 32, 34, 52, 76, 79, 83, 111
Plains, 114-17
Pleistocene, 13-14, 15, 16, 26
Pokharpura formation, 26
Poonch, 79
Porter, W.C., 84
Post-Pleistocene archaelogical hiatus, 117-20
Potwar, 15, 109
Prakash, U., 21
Prasad, B., 81
Prasad, K.N., 1, 3, 4, 10, 11, 68
Prava river basin, 42
Prince of Wales College Museum, Jammu, 3
Proboscidians, 14, 15
Punjab, 15
Purekar, P.N., 82
Puri, G.S., 26, 82, 117
Pushkar lake, 35

Quaternary sediments, 66-97

Rajasthan, 13, 16, 22, 47, 50, 117-18, 119, 126, 128
Rajasthan desert
  Environment, 34-42
Raju, A.T., 68, 72
Ramanagar (J & K), 12
Ramapithecus, 2, 3, 4, 6, 10-11, 12, 16
Randhawa, M.S., 21
Rao, A.R., 82
Ravi valley, 74, 76, 110
Rawat, M.S., 21
Red Crag (East Angolia), 67
Reptiles, 15
Rice, 49
Rikes, R.L., 120
Rimbiara valley, 26
River terraces, 72-6, 82-4, 95, 103-5, 110
Robert, R.D., 26
Robinson, J.T., 7
Rodents, 14
Ropar, 121
Ror village, 74
Roy, D.K., 78
Rupshu (Ladakh)
  Quaternary sediments, 86
Rythen, 78

Sah, S.C.D., 21, 24
Sahni, B., 11, 21, 77
Sahni, M.R., 67, 70, 71, 73, 74, 98, 101
Sahni Institute, 35
Saluikha, S.K., 21, 22
Sambhar salt lake, 35, 37, 41
  Pollen diagram, 40
Sanghao cave, 113, 127
Sangla, 87
Sankalia, H.D., 15, 83, 108
Sarai Nahar Rai (UP), 47
Saraswati valley, 120, 121
Saroj, H.M., 76, 110
Sastri, V.V., 4
Sastry, M.V.A., 14
Sauer, Carol O., 118
Saxena, A.N., 26, 35
Saxena, M.N., 108, 110
Sen, D., 73, 74
Sharma, Chhaya, 22, 43
Sharma, R.S., 122
Sharma, S.P., 21, 22, 25, 69
Sharma, V.K., 73, 74
Shergol, 85
Shyam, M., 98
Simons, E.L., 2, 3, 4, 6, 7, 10, 11
Sind, 126, 127
Sind valley, 79, 83, 84
Sindri Fort, 47
Singh, B., 75
Singh, D., 79, 80, 84
Singh, Gurdip, 22, 26, 29, 32, 34, 35, 36, 38, 39, 40, 41, 47, 118, 119, 120, 121
Singh, H.P., 21, 22, 23, 25
Sirsa valley, 74
Śivalik Hills, 66, 68-9
  Environment, 22-5
  Location, 98
  Man's habitat, 98-106
  Primate palaeontology, 1-19
  Quaternary sediments, 69-72
Śivalik Orogeny, 109
Sivapithecus, 2, 3, 4
Soan culture, 15, 110, 111, 112-13, 122-3, 128, 130
Sombur, 79, 84
Spate, O.H.K., 115, 120
Spiti valley
  Quaternary sediments, 86
Srinagar, 78, 84, 111
Steudel, K., 7
Stone Age artefacts, 74
Stone Age tools, 15, 16
Sub-Himalayan terrain, 114
Suids, 14
Suneja, I.J., 66, 82
Suru river, 84, 85
Sutlej valley, 110, 115-16
  Alluvial deposits, 87
  Quaternary sediments, 87

Tatrot Formation, 14, 25, 67, 69
Tattersall, I., 1, 11, 12
Tawi river, 76, 110
Taylor, 15
Tethys Himalaya
  Quaternary sediments, 76-87
Tewari, B.S., 21, 25, 93
Thar, 115, 120, 129
Theobald, W., 73
Tilwara excavations, 118
Tosmaidan pollen diagram, 29, 32
Toynbee, A.J., 125
Trinkler, E., 85
Tripathi, C., 78, 82
Tso Morar valley, 86
Tylor, Edward B., 130

Udhampur, 76
Ungulates, 15
Urban culture, 118-19, 121

Varma, C.P., 21
Venkatachala, B.S., 21, 23
Verinag, 84
Verma, B.C., 1, 70
Villafranchian, 67
Vishnu-Mittre, 20, 21, 22, 26, 29, 32, 33, 35, 42, 43, 47, 48, 50, 52, 78, 79, 114, 118-19, 121
Von Meyer, H., 1

Wadia, D.N., 2, 13, 14, 67, 78, 79, 82, 117, 127

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TABLE 1

CORRELATION OF TERRACE DEPOSITS OF WESTERN HIMALAYA

SUTLEJ VALLEY (Near Nirath)					*SIRSA VALLEY*	*MARKANDA VALLEY*	*RAVI-CHENAB VALLEY*
						Joshi, 1973	
T_5 (Post-Glacial)	T_7(Post-Glacial) 8.2 m	T_5	Subsidiary Terrace	10 m		T_5(Post-Glacial) 5 m	T_5(Post-Glacial) 3-5 m
	T_6(4th Glacial) 30 m	T_4		30 m	T_3(Post-Glacial) 3 m	T_4(4th Glacial) 15 m	T_4(4th Glacial) 20-7.5 m
T_4(4th Glacial)	T_5(3rd Interglacial) 50 m	T_3	Subsidiary Terrace	50 m 125 m	T_2(4th Glacial) 12 m	T_3(3rd Interglacial) 18 m	T_3(3rd Interglacial) 54-5.30 m
T_3(3rd Interglacial)	T_4(3rd Glacial) 66 m Early Soan pebble tools and small flake tools of chert and numerous Neolithic polished stone celts	T_2	Subsidiary Terrace		Sonian artifacts Neolithic polished celts & numerous antiquities.	T_2(3rd Glacial) 30 m	Late Soan Artifacts. T_2(3rd Glacial) 91-75 m
T_2(3rd Glacial)	T_3(2nd Interglacial) 84 m Early Soan pebble tools	T_1		183 m	T_1(3rd Interglacial) 21 m Pleistocene	T_1(2nd Interglacial) 50 m	Late Soan Artifacts Flakes of Late Soan T_1(2nd Interglacial) 132-120 m
T_1 (2nd Interglacial)	T_2(2nd Glacial) 120 m	Upper Boulder Conglomerate					
	T_1(2nd Glacial) 175 m						

TABLE 2

CLASSIFICATION OF KAREWAS IN RELATION TO VARIOUS GLACIAL STAGES
(After Singh, 1973)

Upper Karewas (609.69 m thick)	Moraines and Terraces of 4th Glacial Stage 3rd Glacial Stage well bedded sands and buff clays, silts with boulders and erratics, buff varved clays and silts. Basal boulder bed. 2nd Glacial Stage	Locally abundant fragmentary plant fossils including rich assemblages of charophyta, rich molluscan and ostracode assemblages. Rare vertebrate fossils, viz., *Rhinoceros palaeindius*.
	Unconformity	
Lower Karewas (1976.40 m thick)	Fine buff and bluish grey clays silts, sands, gravels, varved clays and lignite seams. 1st Glacial Stage Dark carbonaceous shales and siltstones with thick conglomerates and lignite seams. Silts and clays. Pre-Glacial	Well preserved assemblages of fossil leaves, fruit, spores, diatoms and charophyta, locally abundant molluscan and ostracode Assemblages. Vertebrate fossils, viz., *Elephas hysudricus*, *Rhinoceros* sp. and *Cervus* sp.
	Unconformity	
	Panjal Traps and Triassic Limestones	

TABLE 3

CORRELATION OF THE QUATERNARY DEPOSITS OF PARTS OF NORTHWESTERN HIMALAYA

GENERAL CLASSIFICATION		*SWAT KOHISTAN PAKISTAN*		*KASHMIR, LADAKH, SPITI & KINNAUR*	
QUATERNARY	RECENT			Recent Alluvium, Scree, etc.	
	PLEISTOCENE	Kalam Glaciation		1. Glacial moraines and high level Terraces of Kashmir and Kargil basins.	
		Gabrai Glaciation		2. Fluvioglacial and lacus trine deposits of Kargil, Spiti and Kinnaur.	
		Laikot Glaciation	KAREWA FORMATION		UPPER
					LOWER
		Batal Glaciation			
	PLIOCENE				

The Early Man's Habitat in the Śivalik Hills: Some Statements on the Geomorphological Setting

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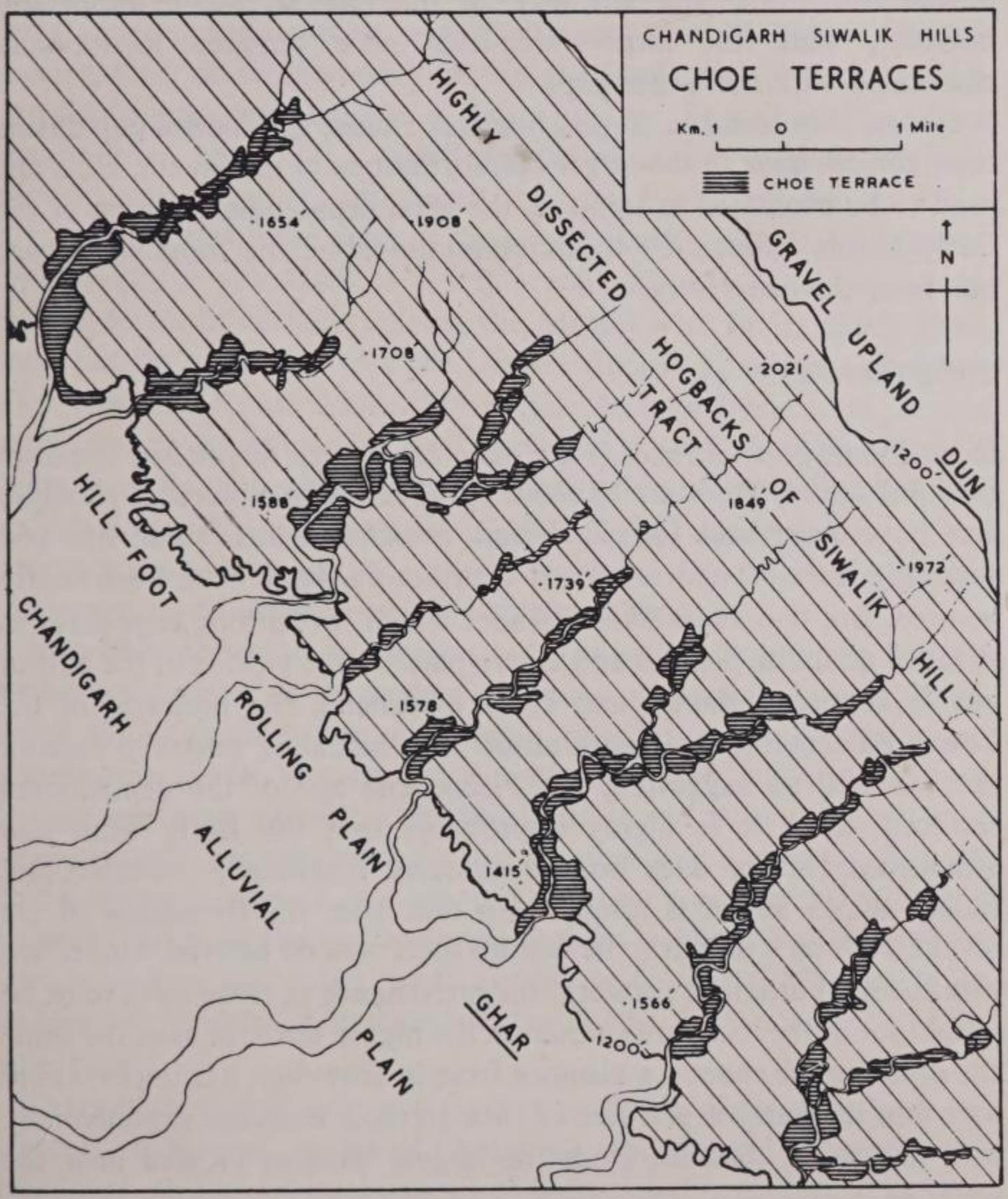
Located south of the Dun and running parallel to it from near Naini Tal in the east to Jammu in the west, the Sivalik Hills form a distinct terrain type. It is characterised by razor-sharp crests, intensely dissected badland topography, perennially unstable slopes of the steep hogback ridges subject to intense mass-wasting, and a very small proportion of gentle slopes and flat lands. Although only 6 to 8 miles wide, the belt extends for a length of about 500 miles. Its average height, however, ranges between 1500 and 3000 ft and its relative relief approximates 400 to 600 ft. What differentiates the terrain from the adjacent Dun and the Punjab Plain is the preponderance of steep slopes (8 to 32°) and still steeper dips (25 to 50°) (Sahni and Khan, 1959; and Shyam, 1970). Scarps near the crest and also at lower elevations are universal. In gross form the belt of the Śivalik Hills displays an elongated hogback with north-facing scarp slopes and south-facing dip slopes.

GEOMORPHOLOGICAL COMPONENTS

Easily, the most numerous of the landform features and the dominant geomorphic agents are the drainage lines of various orders, gulleys, extended gulleys, and *choes* which originate along the northern higher ridges forming the watershed. The major consequent *choes* flowing south-west cut across the basic grain of the Śivalik Hills and debouch onto the Punjab Plains through large water-gaps. While the random and directed movements of the Early Man and the animals he was chasing must have encountered formidable difficulties of the wild rugged terrain of the Śivalik Hills, the numerous water-gaps permitted


CHANDIGARH SIWALIK HILLS
CHOE TERRACES
Km. 1 0 1 Mile
CHOE TERRACE
N
HIGHLY DISSECTED HOGBACKS TRACT OF SIWALIK HILL
GRAVEL UPLAND
DUN
HILL-FOOT
CHANDIGARH ROLLING PLAIN
ALLUVIAL PLAIN
GHAR
1654'
1908'
1708'
2021'
1588'
1849'
1200'
1739'
1972'
1578'
1415'
1566'
1200'

a free exit from, and entrance to the habitat. More important, however, were the large three-level *choe* terraces locationally associated with the water-gaps.

Choes, *choe* terraces, slopes, hogback ridges, and hidden cup basins form the complex of the larger landform units in the Śivalik Hills and need to be evaluated in terms of the geomorphological setting of the Early Man's habitat. Of these, unquestionably, the most significant has been the *choe* terrace.

CHOE TERRACES

Depositional *choe* terraces (Fig.) have never been mentioned in geological and survey literature let alone systematically explored. Probably, they have never been identified, and, because of their small size and strikingly lineated and restricted distribution, have been persistently ignored. But it is these *choe* terraces which reveal long exposures in strips of quartzite pebbles and at two places have yielded to the author pebble choppers, flakes, and cores evidencing the presence of the Lower Palaeolithic Soanian Culture and indicating potential factory sites as well as suggesting the Pleistocene age of the depositional surfaces. Since it is highly improbable that the Early Man had established factory sites on the adjacent perennially unstable and sliding slopes and it is also known that after the formation of the Śivalik Hills as a topographic feature there was no alluvial connection with the Dun drainage network, the provenance of these tools must be sought for in the local area either on the higher terraces near the same site or along the *choe* at a distance from it. However, it is important to note that the number and size of *choe* terraces decrease exponentially with increasing distance from the largest terraces located near the water-gaps.

Within the Śivalik Hills at least three terrace levels can be identified universally and distinguished on the bases of topographic elevations, surficial materials, amount of dissection, the revealed stratigraphic sequences, and areal extent. The highest terrace level about 50 ft from the *choe* bed, is distinctly an erosional surface having a thin veneer of coarse grus brought down the adjacent slopes by colluviation and developed directly on the steeply dipping Upper Śivalik or Boulder Conglomerate beds. On the other hand, the middle level is located about 35 ft below the highest, is depositional-abandonal in genesis and reveals a fully preserved stratigraphic sequence correlated with the

fluctuating stream discharges, fluvial transportational energy fluxes, unilateral channel shifting, and Pleistocene and Holocene climatic changes. It is on this terrace level that the Soanian pebble tools, chopper, flakes, and cores have been discovered by the author. The lowest terrace level, about 14 ft high from the *choe* bed, is of Recent age, depositional in nature, and reveals truncated stratigraphy.

Concurrent with the uplift of the Upper Śivalik beds and the formation of the Śivalik Hills as a topographic feature were formed the highest levels of terraces during the Mindel-Riss Interglacial. Thus, these can be correlated with the late Pleistocene T_3 of the antecedent river terraces (Khan, 1970). Since these terrace levels were formed soon after the Śivalik uplift, they are found located above the Boulder Conglomerate. This observation is supported by the findings of Bhatia and Mathur (1973) and Sahni and Khan (1959). Being the oldest, the highest terrace levels are the most intensely dissected while the middle and lower levels display simpler terrain outline.

Two points need to be emphasised: the *choe* terraces can be correlated with a part of the terrace sequence of the major rivers, Beas, Sutlej, Ghaggar, Yamuna, and Ganga. Secondly, since all the major consequent *choes* flowing north-south and the subsequent ones flowing east-west rise within the Śivalik Hills and these drainage lines have remained unconnected, during the post-Śivalik period, with the Dun drainage system, it is clear that the gravels and pebbles forming the basal layers of the terraces were derived locally from the Boulder Conglomcrates and other local Śivalik beds. Early Man carrying pebbles and tools from the Dun into the Śivalik Hills is, at best, highly improbable.

Analysis of stratigraphy and transverse profile of the three types of terraces, high-level erosional bedrock, middle-level depositional-abandonal, and lower-level depositional-erosional occurring along the large, consequent, transverse *choes* suggests:

(a) a genetic model in which aggradation, channel shifting, abandonment, and entrenchment were the simultaneously operating major fluvial morphological processes;
(b) the processes were immediately related to the local hydrological changes consequent upon the secondary climatic fluctuations, and ultimately associated with glacial and interglacial conditions prevailing in the main Himalayan tracts;
(c) during the long Mindel-Riss Interglacial deep entrenchment forced

by local tilting was followed by wide lateral planation effected with large seasonally fluctuating discharges characterising the warm phases, and with the gradual onset of terminal cool phase and reduction in discharge aggradation became more pronounced;

(d) during the subsequent much shorter glacials and interglacials respectively arid phases were marked by deposition dominating over lateral erosion and restricted channel shifting and wet phases were characterised by shallow lateral erosion reducing effective deposition and increased shifting; and

(e) deposition of terrace mass continued from Mindel-Riss Interglacial to Wurm glacial resulting in a continuous increase in net elevation of depositional terrace which emerged as a topographic surface in Early Holocene. At many places this surface has been eroded to varying depths exposing the lower depositional layers. There were two warm and humid periods, the longer Mindel-Riss Interglacial represented by very thick boulder beds and the shorter Riss-Wurm Interglacial revealed by pebbly silty clay. In the latter humidity was much less and the discharge was smaller. Similarly, there were two cold and arid periods, both fairly long but shorter than Mindel-Riss Interglacial, the Riss Glacial and Wurm Glacial and Holocene expressed through silty clay and clay loam layers, the latter a bit more humid than the former.

DRAINAGE NETWORK

Almost simultaneously with the uplift of the Śivalik beds and very rapidly a high-density and a high-frequency drainage network slashed through the entire area. All the genetic types of streams, consequent, subsequent, resequent, and obsequent, mostly ungraded and steeply sloping thalwegs with conglomerate barriers outcropping on them, and choked with debris and pebbles, evolved dramatically during a short geological period. Of the four types the consequents flowing on the long northeast-southwest extending dip-slopes have been the dominant drainage lines and the principal organiser of the evolution of terrain. During the long Mindel-Riss Interglacial the entire drainage network carried an enormously large discharge and traction load. Since the major part of eroded material was being transported out of the Śivalik Hills the adjacent slopes were evolving in response to erosional activities, particularly gulley erosion and mass-wasting. Even

the larger consequent could not develop into the locales of deposition. The formation of the intricate drainage network was not only accelerated but spatially expanded by high-intensity, large, monsoonal rainfall, lack of continuous cover of forest vegetation, and easily erodible unconsolidated Śivalik beds. During the succeeding epochs of the Riss and Wurm Glacials and the Riss-Wurm Interglacial, in the continually increasing semi-aridity or sub-humidity of climatic conditions the network developed a geometry that has persisted, more or less unchanged in its gross outlines, to the present times. From that time onward the larger *choes* and their innumerable tributaries were transformed into ephemeral, intermittent, and seasonal drainage lines with beds littered at many places with pebbles of potential use to the Early Man. Whether it was with culture-contact processes or the actual movements of the Early Man, the spatial spread of Palaeolithic cultures was operationalised through the innumerable drainage lines of various orders.

While the interior parts of the badland terrain were approached through the small, labyrinthine gulleys, which also provided the escape routes, short-cut intrusions, and connected the north-south lineated *choe* valleys across the interaction barriers of the ridges extending parallel to them, the *choes* and the *choe* terraces carried the longer movements. Through them the Early Man penetrated into the Śivalik Hills and occasionally strayed out of it. Also, the *choes* brought down the quartzite pebbles and deposited them in the *choe* terraces where these were made into choppers, flakes, and cores. Since movements did take place very frequently through the tributary *choes* and gulleys over short distances, it is possible to discover in them stray stone tools left behind by the Early Man.

ANTECENDENT RIVERS AND THEIR TERRACES

Although far less in number, the really large perennial rivers, Ganga, Yamuna, Ghaggar, Sutlej, and Beas, all antecedent to the Śivalik Hills, knife across it through gorges flanked by fluvial-depositional terraces occurring in a model sequence of five surfaces. These terraces and the gorges have great tectonic and climatogenetic significance for geologists and geographers and in the understanding of the Early Man's habitat for the prehistorian-archaeologists. Mohapatra's collections (1966, 1967, 1968/69, 1972, and 1973) of Palaeolithic Soanian pebble tools from these terraces of different and widely separated

areas can be interpreted in terms of the climatic and tectonic changes as well as the changing habitability conditions of this terrain type for the Early Man. Many of the terraces of these large rivers and of their larger tributaries have neither been studied geomorphologically nor for their prehistoric-archaeological contents. These are basically gravel terraces and in all the five levels quartzite pebbles have been observed occurring in either patches or short linear stretches. Gravels and pebbles occur in abundance along the deeply-entrenched gulley banks and right on the terrace slopes. Mohapatra's finds forestall any criticism against the contention that all these terraces had provided sites for temporary stay of the Early Man in his widely-ranging movements. It is in the sanctuary of the terraces that the Early Man lived and died. Here were to be found the raw materials for his tools and the wide and long and flattish ground for him to hunt the animals. Water was provided by the perennial rivers flowing in close proximity.

The terraces of the larger tributaries are located at several places at elevations of 20 to 30 ft from the adjacent stream beds and have therefore been able to preserve themselves against flooding and fluvial erosion. Interestingly, the tectonic and climatic events which entrenched and rejuvenated the streams also uplifted the adjacent terraces, both linear and cuspate in form. It is clear from their location in the gorges of the Śivalik Hills that all the terrace levels were created subsequent to the Śivalik orogeny, and hence need to be correlated with Mindel-Riss and Wurm glacials and Mindel-Riss and Riss-Wurm interglacials. None of these is a bed-rock, erosional surface although the thicknesses of deposition vary between the levels in a clearly recognisable order. In the Ghaggar terraces the depositional thicknesses of 51 ft and 97 ft in T_1 and T_5 are indeed striking. So is the elevation of about 400 ft of the T_1 surface from the Ghaggar bed. In the Doon Valley the figures are 400 to 700 ft (Nossin, 1971). The gorge, the associated terraces, the straight outline of the high river-cut scarp on the east of the Chandi Mandir railway station and the rightangular bend near the water-gap are all highly suggestive of the antecedent nature of the Ghaggar. It maintained the antecedence along transcurrent fault which originated simultaneously with the rise of the Śivalik Hills to their present height. Both the gorge and the river-cut scarp are aligned with this fault. Once the gorge was formed the movement of the Early Man between the Lower Himalayas, the Dun, the Śivalik Hills, and the Punjab Plain was both faciliated and accelerated and the Palaeolithic culture could rapidly extend its domain. Finds of pebble

tools made by the author on the cusp terraces east of the Ghaggar river and by Mohapatra on Ghaggar terraces (1966) provide supporting evidence. It needs to be pointed out that Ghaggar originates on the south-western slopes of lower Himalayas a little west of Sarahan in Sirmur District and is entirely rain-fed and never received glacial or snow-melt water. This makes it unique among the antecedent rivers cutting across the Śivaliks. The fluctuations in its discharges, therefore, cannot be directly correlated with waxing and waning of glaciers in the Himalaya and hence indirect correlation with monsoonal changes and contemporaneous tectonic events becomes necessary for the understanding of these terraces.

HIGH, CUP-SHAPED BASINS

Locked in the main body of the Śivalik Hills are innumerable, small fairly high basins, about 100 to 150 ft from the adjacent colluvial cones of the piedmont strips. Deep, cup-shaped depressions, they are surrounded on practically all sides by randomly arranged network of ridges, have flattish beds measuring some 2000 to more than 4000 sq. yards, and mark the confluence of several gulleys and extended gulleys descending from the adjacent slopes and forming radial centripetal patterns. Beginning as erosional surfaces the basin beds became the sites of colluvial accumulations and developed into flattish depositional surfaces. Such sheltered basins with beds littered at places with quartzite pebbles might have attracted the Early Man for temporary stay and could also have served as trapping pockets for hunting animals. Massive colluviation and mass-wasting, however, render the search for the presence of Early Man and his tools in this landform facet a difficult task. Where the local gulleys are deeply entrenched into the basin bed and pebbles are exposed the explorer might be rewarded.

CONCLUSIONS

Early Man encountered a basically hostile geomorphological setting in the Śivalik Hills. Wild, intensively dissected topography created immediately after the Śivalik orogeny and in the Mindel-Riss Interglacial and comprising formidable hogback ridges prevented him from ranging widely in random directions. Movements were strongly lineated through larger *choes*, water-gaps, gorges, and *choe* and antecedent

river terraces. Inter-valley movements across the interaction barriers of ridges were effected through smaller gulleys and major subsequent streams. Easily the most significant of the landform features in the habitat of the Early Man was the *choe* terrace. These *choe* terraces are mainly depositional in nature and climatic in origin and their stratigraphy and profile are correlated with changing patterns of temperature, humidity, rainfall, and discharge. The larger terraces of the antecedent rivers are both climatic and tectonic in genesis, the antecedence having been maintained through gorges associated with transcurrent faults. These terraces and those formed by the *choes* need immediate exploration by the Quaternary geologists, prehistorians, and geomorphologists for the reconstructing of the Early Man's habitat.

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Pattern of Cultural Growth in Prehistoric North-West India

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> A lepidopterist is a great deal more than a butterfly-catcher, and an archaeologist who is not more than a potsherd-catcher is unworthy of his *logos*.
>
> — Mortimer Wheeler

INTRODUCTORY

The complex nature of the landscape and its evolutionary history, the rapidly changing ecology of the Tertiary *hominidae* and widespread environmental alterations and intermittent diastrophism during Quaternary unroll a kaleidoscopic backdrop with which every matter relating to man in this region of north-western India is linked. Therefore, it is neither possible nor desirable to assess the cultural developments in this region during prehistory solely from the archaeological evidences. With the hope that a multi-disciplinary approach will endeavour to pool several types of evidences brought forth by various sciences, emphasis has been laid in this paper on the general pattern of cultural growth vis-a-vis the environmental background during the whole of the Quaternary period.

Acturial pattern of the food-gathering and food-producing prehistoric cultures in N.W. India reveal strong bond with certain geographical features of the region. In accordance with the varying tempo of human activity during these two distinct techno-economic stages, fair indications are available now of a pattern of shifting foci of cultures. The region of N.W. India comprising the states of Jammu

and Kashmir, Punjab, and Himachal Pradesh, although a compact ecological unit in the broader sense, contains three contrasting geographical features. These are broadly manifested in the three morphological divisions, i.e., the flat and arid dusty plains in the south (average height 400 metres from M.S.L.) followed by a low submontane strip known as the Sub-Himalayan Zone with its savagely eroded Sivalik Hills, numerous *cul-de-sac* valleys and steeply incised gorges (average height 1200 metres from M.S.L.), and the higher mountainous tract of Lesser Himalaya on the north with a few perpetually snow-clad peaks like the Dhauladhar (average height 4,500 metres from M.S.L.).

All evidences that we possess today regarding the evolution of early hominoids and later development of prehistoric cultures till the Neolithic come from the Sub-Himalayan Zone. While the older Śivalik beds in this zone contain a vast hoard of palaeontological evidence in cluding those of the Neogene fossil hominoids, the terraces and other deposits in valleys yield a large number of lithic artefacts belonging to a succession of cultures spanning a major part of the Quaternary. Outside this zone, only in the valley of Kashmir some evidence of Palaeolithic culture has been recently found (Sankalia, 1971; Joshi, 1974) which although very interesting is nevertheless too scanty for any serious analysis. At the threshold of the change-over from parasitic to productive life Early Man in N.W. India seems to have moved out of the Sub-Himalayas and descended to the low alluvial terrain of the flat plains where effective food production had taken place as evidenced by the presence of a large number of small peasant-village settlements (early Neolithic) bordering the foothills (Baluchistan and W. Punjab) which preceded the protohistoric urbanisation So far no prehistoric culture has been found on the plains which interestingly enough is reciprocated by the total absence of early peasant-village culture in the Sub-Himalayan Zone. The Lesser Himalaya as such had always remained out of bounds in the life of Early Man. In fact, above a level of roughly 600 metres from M.S.L. no prehistoric relics have been located anywhere in N.W. India right from Hazara to Nainital (Kashmir excluded). A careful analysis of various stages of development of Sub-Himalayan terrain right from the Middle Miocene (Himalayan Orogeny – Saxena, 1971) onward reveals very fascinating evidences relating to the changes in the land-forms, climate, and vegetation and, which when seen in proper perspectives explain the development of certain contrasting ecological

niches and their inevitable strong cultural attachments.

PART I. PATTERN OF POST-ŚIVALIK GEO-TECTONIC AND ENVIRONMENTAL CHANGES

The Pleistocene Set-up

The Śivalik Orogeny at the end of the Mindel brought forth massive changes in the Sub-Himalayan Zone. Uplift of the Outer Śivalik range (Kalachita, Khair-i-Murat and other hills) and related subsidence of the Indo-Gangetic foredeep; trenching and incision of the valleys and gorges of the antecedent rivers by steepening of their courses; draining of the backswamps and lagoons of the Upper Sivalik period; are some of the major evidences of this change. On the whole, the emergence of the entire Sub-Himalayan Zone that we see today as an elevated platform intermediary between the high ranges of the Lesser Himalaya and the low flat alluvial plain had taken place during this period. Therefore, from biological considerations the general terrain condition of the Post-Śivalik Sub-Himalayan Zone could not have been very congenial. Further, progressive desiccation caused by the uplift of the terrain in the immediate past and presence of huge piles of freshly laid washed down coarse sediments in the valleys such as the Lei and Neogal conglomerate, would surely have had a very adverse effect on the ecology of plants and animals. Therefore that luxuriant Śivalik fauna and flora marked in the Dhok Pathan Stage which had inclined towards depletion as noticed in the Tatrot but temporarily withstood during the Pinjore, could not have revived fully due to such environmental condition during the Post-Śivalik period.

This completely new set-up of the Sub-Himalayan Zone brought forth by the Śivalik Orogeny draws a clear ecological break between the Śivalik and Post-Śivalik periods which roughly correspond to the pre-human and human era of this region. Work in Potwar region subsequent to those of H. de Terra and T.T. Paterson (1939) indicate that, Boulder Conglomerate which was supposed to have yielded the Pre-Soan flake artefacts may not be the true Śivalik Boulder Conglomerate. Investigations by W.D. Gill (1954) suggest that this horizon is actually a Post-Śivalik formation (Lei Conglomerates). Therefore, the date of the earliest artefact bearing horizon in the Potwar region so far assigned to the Mindel period on the basis of the dating of the Śivalik Boulder Conglomerate has to be reconsidered.

Moreover, actual presence of a cultural sub-stratum recognisable as Pre-Soan is now being seriously questioned.

Following the Mindel Glaciation in the Himalaya the evolution of the terrain morphology in the north-western Sub-Himalayan Zone had been more or less of a uniform pattern. Due to this, identical cyclic depositional activities among all major Himalayan rivers and their chief feeders originating from the perpetually snow-bound areas are noticed in this zone (Mohapatra, *ms.*). Five terraces have been generally observed in the Indus and Soan (de Terra and Paterson, 1939). Beas (Mohapatra, 1973), Ravi, Chenab, Tawi (Saroj, 1975), and Sutlej (V.J. Gupta, M.N. Saxena personal communications).

Ranging in age from early Middle-Pleistocene to late Holocene these terraces and other Quaternary deposits when carefully observed in the light of geo-tectonic developments in this area provide interesting deductions on the changing ecological pattern of the terrain through this vast span of time. The cultural changes observed in this region will be better understood when viewed from this angle and many a question get reasonably answered when we take cognisance of the contrast between the Pleistocene set-up of N.W. India vis-a-vis the Peninsula.

The Terrace 1 of the Sub-Himalayan rivers is the result of the erosional activities of the Mindel-Riss fluvial discharge. During this period the post-Śivalik conglomerate (Lei, Neogal and other higher conglomeratic deposits) was redistributed over extensive areas. A comparatively warm climate is indicated by the occurrence of a fauna of Lower Narmada type in this terrace deposits (de Terra and Paterson, 1939) during which the Early Soan Culture flourished.

Towards the close of the Middle Pleistocene a drastic change in the ecology of the Sub-Himalayan region is indicated by the thick mantle of loessic silt known as the Potwar Loess. Dated to the period of Riss Glaciation, this thick cover was a very widespread phenomenon the remnants of which are found on Terrace 2. There are evidences of tectonic upheaval of considerable magnitude during this period. It is indicated by the Dagshai beds seen pushed up over the alluvial clays and conglomerates at Mastanpura and in the Nalagarh *dun* (Lahiri, 1936). The development of a major fault in the Upper Śivaliks known as the Pinjore Fault and formation of the Sirsa-Jhajra divide concurrent with the emergence of a small *dun* between Pinjore and Nalagarh can also be ascribed to this upheaval (Mohapatra, 1973; *ms.*). At the present state of our knowledge it is difficult to assess the

effect of this diastrophism over the drainage pattern and general meteorological setup of the Sub-Himalayan region. However, there are reasons to agree with de Terra (1939) that the glaciation (Riss) which preceded the disturbance had probably frozen the sources of southerly drainage giving rise to a general arid condition as a result of which finer deposits like Potwar Loess have been laid over a massive stretch of the landscape. To this period belongs the Late Soan Culture.

Terrace 3 of the Sub-Himalayan rivers was formed as a consequence of the Riss-Wurm Interglacial melt eroding away a major part of the Potwar Loess at places close to the channel of the river and subsequent deposition of coarse sand and silt in succession.

Interestingly enough, the diastrophic periods which have already been noticed twice coinciding with the past two glacials occurred again towards the end of the Pleistocene (Wurm?). Evidence of this comes from a large number of instances of tectonic deformities in late geological contexts. These are: overthrusting of the Upper Śivaliks on to almost horizontally disposed Older Gangetic Alluvium (Lahiri, 1936); displacement of worn-away outliers of Krol Nappes and their transport over long distances across the Lower Tertiaries and Śivaliks till the Indo-Gangetic Alluvium; folding in the terraces of the Jaldhaka in the Sikkim-Bhutan Sub-Himalayas and the tilting of the older terraces in the Potwar area. The wholesale uplift of the Srinagar Valley "without any noticeable buckling or contortion of the Upper Karewa beds" (de Terra, 1934: 40) is probably the most significant evidence for this Late Pleistocene diastrophism (epeirogenic rise) which had led G. Dainelli (1922) to estimate a rise of 8000 feet in the Pir Panjal since the second half of the Pleistocene. Pascoe (1964: 2070) thinks de Terra's estimate of 6000 feet may be nearer the truth.

Amidst these sweeping changes in the landscape ultimate development of the Soanian had taken place (Final Soan) coinciding with the final phase of the Himalayan glaciations. The Terrace 4 belonging to this period and containing the relics of this industry is composed of loam, silt, and slope-wash gravels with occasional bedding and lamination. While on one hand the character of these deposits indicates a disturbed depositional environment on the other their mode of occurrence suggests the presence of local temporary bodies of water and scanty rainfall condition. The environment of the Wurm period was generally marked by an overall aridity which was a somewhat global phenomenon (Zeuner, 1953; Wissmann, 1956).

It should be made clear at this stage that although there is no direct

evidence of glaciation anywhere in the Sub-Himalayan region the Glacial Chronology of the Himalayas has been adopted in this work. It becomes imperative for demarcating the cultural stages which were so intimately bound to the environmental changes that had taken place right at the foot of this massive mountain chain as direct effects of changing climatic regimes at higher altitudes.

In the Sub-Himalayan region absence of widespread weathered soil horizon or indications for alterations of rocks *in situ* due to prolonged weathering under heavy humid condition, when taken into account along with the unconsolidated friable nature of the deposits on the terraces with thin soil cover, discount any possibility of high precipitation comparable to the pluvials in the tropics. The most that the sedimentary evidences suggest is the periodical increase in the moisture content of the soil due to the terrain being flooded by the rivers receiving the glacial melts during the warmer periods (Interglacials). Not only that the atmospheric condition was never extra-humid, the evidence of the extent of loess spread suggests a severely deteriorating meteorological condition during the best part of the Post-Śivalik period. The numerous small *cul-de-sac* valleys (*duns*) in the Sub-Himalayas due to their peculiar topography had more or less withstood this severe condition. This is attested by the cluster of lithic localities on the terraces which would not have been there so exclusively had there been no concentration of animal and vegetation within such valleys. An instance of this type of Late Pleistocene set-up has been noted in the Nalagarh *dun* where palaeontological evidences suggest negligible current action but presence of moderate lacustrine to marshy condition providing adequate moisture for the support of a reasonable molluscan fauna and flora (Bhatia and Mathur, 1971).

The most outstanding pecularity of the Sub-Himalayan Zone is that neither the Pleistocene glaciations had ever descended to this altitude nor was there any pluvial period as such. Cultural progress shows maximum growth during the warm-humid conditions of the interglacial phases when probably the terrain enjoyed fair tectonic stability.

Holocene Developments and the Shifting Foci of Human Activity

The final stage of the evolution of the Soanian technique and typology is seen in a small flake-tool industry known by the name of Final Soan and/or Evolved Soan which is datable to the last aggradational cycle

of the Late Pleistocene. Almost invariably everywhere in the Old World homotaxial lithic industries have been found to contain in them a preponderance of blade element with a strong tendency towards micro-facies. These have been technically considered as the precursor of the Mesolithic micro-blades of the Early Holocene period. In this regard the Final or Evolved Soan industry is an exception. In it not only the small blades and corresponding longish cores are conspicuously absent, no trace of a blade-producing technique is to be found either. Hence the point which merits special emphasis is that at present there is hardly any evidence in any of the hitherto known lithic industry in the region of N.W. India, including the one belonging to the Late Pleistocene, of a genetic growth of blade technique which could have been developed and elaborated to form the basis of a microlithic industry during the Post-Pleistocene period. Coupled with this the actual absence of Mesolithic microliths in the region of N.W. India makes the Late Quaternary cultural developments in this part a very complicated issue. Excepting the Sanghao Cave and certain disputable microlithic localities in Kashmir Valley, which however are situated in the extreme margin of the region under discussion, the absence of this prolific Holocene industry in the vast stretch of the Punjab foothills and plains has not yet drawn proper attention. About the problem D.H. Gordon (1960) thinks that "if the Mesolithic people lived on the banks of the five rivers, it is probable that all the evidences of their existence has been swept away by floods or buried under alluvium" (*Ibid*: 21). R.E.M. Wheeler tries to draw attention particularly to the 'significance' of the absence. Not suggesting the causes specifically, he points out to parallel situations in East Bengal, Orissa, Assam, and S.E. Asia as a whole (Wheeler, 1959). While Gordon's suggestion of total obliteration of evidences due to flood during an unspecified period or periods sounds not only platitudinous but improbable, Wheeler's observations regarding parallel absence of microliths in the areas named by him are no more valid. Therefore, while on one hand explanations for the actual absence of an important stage in the hunting-gathering career of Early Man in N.W. India has to be sought, on the other the conditions and antecedents of an early food-producing stage represented by several Neolithic sites in the foothill *duns* (Mohapatra, 1974a) have to be viewed in proper perspective. Gordon and Wheeler have nevertheless thrown provocation to search for a solution of the Holocene environment of the terrain.

Sub-Himalayan Terrain at the end of Pleistocene: A Model Hypothesis

It is well known that in most of the regions of the world slow extinction of great herds of Pleistocene tundra fauna during the post-glacial period, due to reasons of changed environment, forced man to adopt a more arduous life of chasing-hunting thus equip himself with suitable new tool out-fit. The open grass land, including the woodlands of the forest-tundras as natural habitat of such solitary small game that had survived, wherever present, attracted the Mesolithic folks to those areas. Although not much of data regarding this period are available in India, still somewhat similar habitat must also have been preferred by man and animal of the Mesolithic period in the peninsular and extra-peninsular region can be deduced from the heavy concentration of the aceramic microlithic sites on undulating plains, plateaus, sand dunes and open rock-shelters. In view of this, the absence of Mesolithic folks in the *duns* and foothills of the Sub-Himalayas may be explained as due to the dispersal of fauna from the region at the wake of Holocene desiccation. Widespread aridity in climate from Kashmir to Rajasthan during the post-glacial period is now being revealed by palynological studies of samples coming from widely scattered localities in this region (Mittre, 1974).

Condition of the Plains of N.W. India during Holocene

Can the absence of Mesolithic culture on the plains be explained through the same hypothesis of desiccation and dispersal at the end of the Pleistocene? Some of the evidences that we shall discuss presently do lead us to a somewhat similar conclusion.

Right below the outer slope of the Śivalik Hills (*Bhabar*) the whole of the surface of the plains is composed of the 'Older Alluvium' (*Bhangar*) and the Recent flood-plain deposit of various rivers or the 'Newer Alluvium' (*Khadar*). The beginning of the Older Alluvium can be traced back to the period of Potwar Loess (Riss) when an enormous area of some 60,000 square miles was supposed to have been covered by this predominantly wind-borne stuff (de Terra, 1939). Since then this alluvium which continued to be deposited, eroded and redeposited during the succeeding 3rd Interglacial and 4th Glacial, as discussed above, gave way to a new type of alluviation (Newer Alluvium) immediately at the end of the Pleistocene. Due to changed

climatic conditions and suspension of epeirogenic movements in the Early Holocene period the Himalayan rivers flowing through the plains firmly and deeply trenched their courses through the older valley sediments. Consequently, the flood-plain deposits of this period came to be known as Khadar or the Newer Alluvium. "The bulk of this formation, which is usually from 500 to 800 feet thick, is typically a uniform, unconsolidated, unstratified, structureless, wind borne drift" (Pascoe, 1964: 1927). It has been deeply dissected into labyrinthine network of steep ravines known as *Khuddera* (in Potwar plateau) giving rise to a bad-land topography (Spate and Learmonth, 1967). "The change from the river gravels and sands of the Older Alluvium to mainly aeolian Newer Alluvium in these parts indicate a desiccation of the surrounding country" (Pascoe, 1964: 1928). Although one may not agree with Pascoe regarding the whole of the Newer Alluvium as aeolian in origin, its finer upper part surely displays evidence of intense wind activity during the period of its final deposition. This is a very important evidence regarding the ecology of the Punjab plains at the beginning of the Holocene.

The discovery of the sub-surface beds of marl supplement the above evidence on Holocene climate. These deposits which have been brought to light recently also provide some very interesting deductions as regards the ancient hydrography of the plains. At places nearly six feet in thickness these beds occur two or three feet below the surface mostly in the southern extremity of the plains bordering the Thar in the districts of Hissar, Mahendragarh and Gurgaon (Haryana). The sub-recent origin of these beds is suggested by the occurrence in them of many fossil foraminifera and ostracoda comparable to living taxa (Bhatia and Khosla, 1967). The conditions for the formation of marl make it obvious that there were big stretches of water in this area. Today a string of brackish pools, just below the 700 ft contour at the foot of the plateau marked by the Thar, can be observed which usually dry up during the hot weather.

Arthur Geddes (1960) thinks that "lakes would have formed readily along the drainage line when the Himalayan rivers distribute the waters and sands over their cones" (*Ibid.*: 259). Therefore, these lakes "mark the shifting belt of the Yamuna-Sutlej water parting" (*Ibid.*: 260) which were once connected with each other and "drained to the Yamuna by a cut through the ridge" (*Ibid.*: 259). For accepting these observations of Geddes, two questions have to be answered. (1) To what period or periods the shifting of the belt of Yamuna-Sutlej water

parting is to be ascribed so that the marl beds may be correlated with these lakes? (2) What was the precise reason for sealing off of this cut in the ridge (Delhi-Aravalli Ridge) and separation of the lakes from each other which could have accelerated the formation of marl in the basins?

In our opinion if the lakes were ever interconnected and were drained to the Yamuna through a cut in the ridge it could have been possible only some time during the Pleistocene because the post-glacial rejuvenation and trenching of the present bed of the Yamuna would surely have led to the sealing off of the alleged cut in the ridge (Note: Geological evidences do not show any cut in the ridge whatsoever). Not proposing to enter into the controversial discussion regarding the fossil hydrography of the Punjab plains, the best that can be said on the brackish basins is that these at present have more depressions. The marl-bed localities still collect surface and/or artesian water during rainy season on which count they could be the living examples of the fossil marl-bed basins.

The two feet or more soil cover over the fossiliferous marls is a typical wind-borne stuff of recent origin. Below the marls lies probably the Older Alluvium which formed the bottom of the basin. From this stratigraphy the period of isolation and desiccation of the lakes leading to the formation of the marl-beds becomes bracketed between the cessation of the deposition of the Older Alluvium coinciding with the end of Pleistocene when the drainage of these lakes was also discontinued due to river rejuvenation, etc., and the beginning of the formation of the top soil. The thickness of this top soil and its resemblance with the upper part of the Newer Alluvium, which is mainly aeolian, are fairly suggestive not only of its recent origin but also of the setting in of that climatic condition under which the Newer Alluvium was laid. From these it can be argued that the interval of three to four thousand years between the end of the last glaciation and the beginning of the Thermal Maximum was probably the period when these isolated lakes contained water in proportion to the increasing desiccation due to the approaching peak of the Early Holocene dry phase. Therefore, it is reasonable to hold that the top wind-borne stuff had accumulated during the Thermal Maximum, i.e., between 5000 and 2500 B.C. simultaneous with the gradual desiccation and subsidence of the basins.

In addition to the above evidences of the Post-Pleistocene desiccation, the nature and composition of the alluvial country do not

pose a very encouraging picture as far as the matter of organic sustenance is concerned. The Older Alluvium being a drift soil (as contrasted to residual soils) is not only poor in plant nutrition but also its impervious clay layers (often storing artesian and semiartesian water) obstructing drainage of the soil (the Kandi zone) and promoting thereby accumulation of injurious salts of sodium and magnesium, give rise to big sterile areas of saline efflorescence. Therefore, barring the strips of flood-plains (*Khadar*) of the big rivers (few actually transversely cross the plains), the major part of the plains was far from being an ideal habitat during Early Holocene period from the Mesolithic point of view. This is further borne out by the rarity of organic remains in the Older Alluvium. The Newer Alluvium in the flood plains although a somewhat better soil, was not only being freshly laid at the time but also contained such chemicals and compounds as to render it unfertile without human effort. A great deal of calcium bicarbonate brought down to the flood-plains by the Himalayan rivers due to accelerated dissolution of the limestone deposits of the outer ranges under conditions of Pleistocene climatic fluctuations, being precipitated in the form of carbonate because of high temperature on the plains, was never conducive to the growth of good vegetation (Puri, 1958).

In addition to the above, the Punjab rivers having a comparatively steeper gradient bring down great loads of sandy deposits to their flood-plains which tend to diminish the pluvial denudation of the surface by allowing the water to sink into the soil (Pascoe, 1964). Therefore, waterlogged unhealthy condition prevailing in the low gradient stretch of the valley was probably another important factor in the ecology of the plains. These considerations have led D.N. Wadia (1957) to think that most of the terrain (Indo-Gangetic Plain) "became firm and dry enough to be habitable for man only some 5000-7000 years ago" (*Ibid.*: 82).

PART II. PROBLEM OF POST-PLEISTOCENE ARCHAEOLOGICAL HIATUS

Desiccation of basins and lakes and accumulation of thick aeolian layers over the marl-beds suggest increasing aridity on the plains as a continuous process right after the Pleistocene. Pedological, palaeobotanical, and archaeological evidences from parts of Gujarat and Rajasthan which fall within the Dry Belt of Inner Asia also lead

to a similar conclusion (Zeuner, 1963; Mittre, 1974; Misra, 1971).

The pre-pottery microlithic culture at Langhnaj dated to 3000 B.C. and the Bagor Mesolithic culture beginning in 4600 B.C. indicate that man came to occupy the arid zone during the Thermal Maximum. Excavations at Tilwara reveal that the dry condition continued as late as first millennium B.C., and so also the Mesolithic culture in parts of Western Rajasthan (Misra, 1971). Therefore, the conclusions which follow are:

1. So far there is no evidence of a Mesolithic culture in the region of N.W. India prior to 5000 B.C. Therefore, a period of about 4000 years between the end of the Pleistocene and the beginning of the Mesolithic in Rajasthan area appears as an archaeological hiatus.

In order to narrow down this blank period recently Allchin *et al.* (1972) have tried to project that the last arid phase in Rajasthan came to an end around 9000 B.C. which helped the growth of a Mesolithic culture at that time from the local Upper Palaeolithic base at Budha Pushkar. Unfortunately due to the empirical nature of arguments and evidences and lack of wider corroborations these conclusions cannot be generalised at this stage.

2. There is no evidence so far of an appreciably higher precipitation in this region, not even in the presently well-watered Eastern Rajasthan, any time between 5000 B.C. and the beginning of the Christian era.

3. That during this period (Mesolithic) man came to settle in this region and continued to live for a very long time under such severe arid conditions has a far greater implication than what has been appreciated so far by most of us.

4. Once settled, the hunting food-gathering man had made quick progress towards urbanisation in this arid zone despite environmental hazards. Within a span of two thousand years man in this region had achieved all that was needed to lay the foundation of civilisation (Pre-Harappan and Harappan Cultures along the lost bed of the Saraswati).

In this context recent pollen data from the saline lake beds of Northern Rajasthan, recovered and worked out by Gurdip Singh (1971), calls for a serious re-evaluation of our total stock of evidences relating to the Holocene ecology of the plains. Singh's study has revealed periods of increased precipitation in this area. Although there are serious doubts regarding the reliability of the palynological data in general (Sauer, 1952) and the Rajasthan material in particular (Mittre,

1974), the question which demands critical appraisal and is relevant in the context of the growth of urban civilisation in this area is the proportion of the increase in precipitation, if ever there was any, in relation to the requirements of effective food-production.

Phase II of Singh is a wet period of 500 years between 8000 and 7500 B.C. when precipitation is said to have increased by about 20 to 25 cm, over and above that which is usual for the formation of sand dunes. Since these dunes generally occur where rainfall is less than 20 cm (going as low as 2 cm), one wonders whether it will make any substantial alterations in the landscape with reference to food-yielding vegetations, if another 20 to 25 cm are added to it. A rain of 45 centimetres in an area where surface temperature is very high does not take it out of the range of arid zone. For instance, the Budha Pushkar area today receives approximately 52.3 cm of rain despite which it has remained a sandy waste without much of vegetation (Allchin *et al.*, 1972). However, it is interesting to note that excepting the disputable Budha Pushkar evidence there is no record of man's occupation (Mesolithic) of this area at this time in spite of this double or more increase in the precipitation. The author had this in view when he drew the attention to the problem of occupation of the arid areas of Rajasthan and Gujarat by Mesolithic man at the peak of the Thermal Maximum.

Between 7500 and 3000 B.C. (Phase III of Singh), according to Singh, Rajasthan area had experienced intense aridity leading to semi-desertic conditions. This is true when compared with other arid areas of Inner Asia. During this period man first comes to settle in Rajasthan as Mesolithic hunter. But the view that incipient food-production might have taken place at this period by cultivating cereals with the help of slash and burn method (Singh, 1971) is open to serious doubt because of the association of this method with sub-humid environments.

The difficulty in extending Singh's observations in Rajasthan to the entire area of N.W. India, which will include the Western Rajasthan (The Thar) and the south-western part of the Punjab plains, lies in the fact that the pollen data in question come from locations close to the Aravalli range which usually receive more rain than the areas to the west and northwest. As it has been pointed out above, even if a proportional increase in precipitation (between the Aravalli area on one hand and the Thar-Punjab plains on the other) at a particular period is advocated, whether such an increase will be enough to

support agriculture without the help of irrigation is a moot point. Today we know that areas "under 15 to 20 inches" (38.10 to 50.80 cm) of rain are "practically entirely dependent on irrigation. . .". Those between "25 to 35 inches" (63.50 to 88.90 cm) "are worse off than the really arid north-west, since the rainfall is usually, but only precariously, adequate for crops. In such marginal regions agriculture is indeed balanced on a knife edge. . ." (Spate, 1960: 57). Keeping this in view the increase in precipitation between 3000 and 1800 B.C. as suggested by Singh's researches (Phase IV a), will not substantially boost the food production during the Indus valley period, less so it being the main condition as is perhaps thought by many, till it is proved that the rains in the region of N.W. India during this period were actually much more than 35 inches or 88.90 centimetres.

Environmental Deterioration vis-a-vis Culturai Expansions

As regards the possibility of such a high precipitation in the Dry Belt of Inner Asia, of which N.W. India is a part, we have no evidence anywhere. Evidences contrary to this, available from the valley of the Indus itself, have led Rikes to hold the view that "the climate and rainfall in Harappan times were probably no significantly different from those of today" (Rikes, 1965: 199). Analysis of the fossil hydrography of the mythical Saraswati Valley (the present dried-up beds of Ghaggar, Hakra, and Nara) supplement Rikes' views as far as the Indian part of the Punjab plains is concerned. Spate and Learmonth (1967), after examining all points of view on this problem, sum up their own observation as ". . .it is unlikely that this broad bed (of dried-up Saraswati) was ever completely filled with water; the fertility of its loamy levels when water can be brought to them, and its striking definition between the bordering sand-ridges, are responsible for the local belief in the existence of a river of first magnitude. This is very unlikely. . ." (*Ibid.*: 536). ". . .the main action of the Ghaggar drama has not been by way of catastrophic changes in the river pattern but by slow unspectacular, but cumulatively decisive deterioration in the ground water condition largely added by human activity. And there is the menace of the spreading Thar" (*Ibid.*: 538).

Recent palynological researches tend to validate the above observation. These reveal little change in climatic condition any time during the past 6000 years. Along with the increasing aridity certain biotic influences have been suggested for the creation of the desertic condition

in N.W. India (Mittre, 1974).

Towards the wane of the Thermal Maximum in the Dry Belt of Inner Asia spring up a number of massive urban centres of which the Harappan settlements at Lothal (and now Surkotda) in Gujarat, Kalibangan in Rajasthan, Ropar in the Punjab, Harappa and Mohenjodaro, etc., in Pakistan are Indian examples. The rise of this civilisation has been interpreted by many as an indication of general amelioration of the environmental condition in N.W. India presumably as results of higher precipitation. Interestingly enough, no such interpretation has ever been put forward in the case of Egypt, Mesopotamia, Levant and other well-known centres of Early Urban cultures situated within the same Dry Belt. In these regions the spread of food-producing cultures from the hill-flanks to the stream lands of the Fertile Crescent has been interpreted as consequences of the problems of climatic change, population increase (Flannery-Binford model), and scarcity of cultivable land (for transhumance) as a result of which an attempt was made to expand the ecological range of certain heavily exploited resources, and certainly not due to the attractions of the river valleys as better rainfall areas as we seem to think in the case of N.W. India. The presence of layers of drift sand in the refuse of occupation sites such as Faiyum and Merimde speak of great aridity during the period of their occupation. In the Fertile Crescent the question of growth of urban cultures can be associated with the problem of 'Challenge' of the landscape and man's 'Response' to it by means of organised human efforts like irrigation, alternate cropping, etc. The thing which mattered most to the early food-producing communities settled in the stream lands in the Dry Belt is the annual flood of the rivers renewing the fertility of the soil. North-western India being part and parcel of the same Dry Belt could not have been an exception. There are ample evidences of recurring floods at every Harappan site.

The point which emerges from these discussions is that the environmental condition of N.W. Indian plains, despite minor oscillations from time to time, had steadily advanced to greater and greater aridity right after the end of the post-glacial release of melt water from the antecedent drainage areas. Culmination of this deteriorating condition probably came between 1000 B.C. and 300 A.D. (Stage V of Singh) when the Saraswati of the Ṛg Veda completely lost herself amidst the sandy wastes of the Thar. This may be the major cause for the people of the Ṛg Vedic period for continuing to adhere to their

pastoral economy as long as they remained in the Punjab (Sharma, 1973), which was however for a brief period only. Rapid shifting of their settlement eastward to the Madhyadesa towards the Later Vedic period where the actual flowering of the Early Aryan Culture (Epic Aryans) took place amidst the ideal surroundings of the Ganga-Yamuna doab clearly speakes of the type of incentive and inducement the Early Aryans had received from the plains of the Punjab right after emerging on to it from the fastness of the western hills.

PART III. PATTERN OF CULTURAL GROWTH

Pleistocene

Attention has been drawn above to the controversial nature and disputable provenance of the Pre-Soan flakes. This makes the beginning of the Sub-Himalayan lithic culture during the Mindel period doubtful. Therefore, the first appearance of Early Man in this region can be firmly dated to the Mindel-Riss Interglacial as attested by the Early Soan industry. Character of individual Soanian industries have been discussed in varying detail by so many original investigators that the time probably has arrived to synthesise and consolidate the main trends.

It is now apparent that appellatives like 'Chopper-Chopping tool' or 'Pebble-Tool Culture' applied to the Soanian inadequately express its character. Similarly, equation with the Oldowan grossly distorts its picture (Mohapatra, 1975). The distinctiveness of the Soanian is only appreciable when viewed through its entire range of artifactual outfit. The first to be noticed is the surprising adherence to pebbles and cobbles as artefactual blanks right from the Early Soan till the Final/Evolved Soan. The position did not change even when small flake-tools and tiny choppers came to replace heavy duty tools. The author has opined elsewhere that "meticulous selection of pebbles of suitable shape, size and consistency keeping in view the desired type and function of the tool was an inseparable element in the Soanian technique; conceptually almost at par with the flake-blanks in the Levalloisian" (Mohapatra, *ms*., also 1975). Even the penetration of the Acheulian into the Soan culture area did not alter the position.

Another distinctive character of the Soanian lithic tradition is its motivation by the Sub-Himalayan environmental changes. It is demonstrated through the production of flake-tools during the Late

Soan when the region became covered with a thick blanket of loess. While on one hand the arid cold condition of freshly laid loess country restricting growth of vegetation and animal multiplication demanded no great enlargement of the tool-kit, on the other the loess covering wide areas made the pebbles and cobbles scarce by that imposed an economy in the use of this material. Production of several flakes from one pebble would have been an obvious solution which very well suited the limited needs of the period. Taking into account the reappearance of tools on pebbles in a larger proportion in the Final/Evolved Soan industry, specially the proliferation of the pebble scrapers (Paterson and Drummond, 1962), when much of the loess has been eroded away one can further visualise the powerful grip that the Sub-Himalayan environment had over the development of the Soanian lithic complex.

At a very late stage of the Soanian (Late Soan) a developed Acheulian industry seems to have touched the western fringe of N.W. India. It was a short-lived phenomenon which could neither stabilise nor integrate itself within the Sub-Himalayan lithic complex (Mohapatra, 1975). The author has thrown hints elsewhere (Mohapatra, *ms*.) regarding the possibility of the archaic form of *Homo-sapiens* seen at Mugharet-es-Skuhl and Djebel, which seem to have infested greater part of Asia as the author of this Late Acheulian Culture.

Open scattered sites of Early Soan indicate a habitation pattern of temporary nature. In quest of food man during this period had roamed widely over the terrain as a result of which his artefacts sometimes occur in strange contexts like the flat tops of the prehuman Upper Śivalik ridges (Mukerji, 1974). There probably exists a relationship between the pebble-tools and the savannah condition (Clark, 1964) – scarcity of game forcing dependence on vegetation. In contrast to this is the ecology of the Acheulian culture which mainly thrived in the temperate climate, hunting big games with heavy sharp tools. This makes obvious the reason for the Acheulian not sustaining long or penetrating deep into N.W. India.

Incipient occurrence of specialised domestic artefacts in the Late and Final Soan industries might suggest a slow transformation from random nomadism of the Early Soan stage to a somewhat localised habitat pattern towards the finale of this culture. In this context it is noteworthy that the Soanian tool-kit displays a conspicuous lack of precision-grip tools.

On the whole, at the back of the Pleistocene cultural development operate too many converging factors. "The peculiar blending of the diastrophisms with climatic fluctuations, immature topography with geomorphological isolation, and progressive desiccation with dwindling organic sustenance have together given the Soanian the personality of a close-circuit culture. That the environmental hardship was no great deterrant as long as the hominid faculties were alert to the changing needs is amply demonstrated by the continuance of the Soanian for such an enormous length of time. Quite contrary to the idea of Soanian spilling over the limits of the Sub-Himalayas and spreading towards the Peninsula, the very fact that the Acheulian could hardly penetrate reasonably deep into this region, or for that matter any other lithic culture, speaks how strongly the Soanians adhered to their favourite habitat – the peculiar ecological niche. In other words, very few regions in the world reveal that strong grip over the lithic developments as is manifest in the case of the Soanian in the context of the Sub-Himalayas" (Mohapatra, *ms.*).

Holocene

It has been already indicated that the trends of cultural development during the Post-Pleistocene period is largely a matter of conjecture. All evidences that one could lay hands on and which could be applicable in a general way to the entire plain region point to a progressive desiccation during this period. The vast stretches of barren lands and sandy wastes that we see today despite irrigation were probably worse during the Early Holocene. The combined effect of the drift nature of the alluvial cover, strong aeolian activity, imperviousness of the sub-soil, high salinity, low precipitation and high rate of evaporation could not have gone unreflected in the cultural development.

When viewed from this angle, the absence of a Mesolithic culture in this region will appear less intriguing. Obviously, neither the plains nor the adjoining *duns* could command any attraction for the Mesolithic folks. Hence, could it be that due to these circumstances the transitional stage between food gathering and food producing was too transitory in this region so as to leave behind little evidence?

Considering together the absence of a Mesolithic culture and comparatively greater antiquity of food production in this semi-arid region than other places in India, there appears to be a *prima facie* case to go into the details of this question. In this context attention may be drawn

to the highly controversial theory of influx of nomads towards the well watered valleys during the period of intense desiccation resulting in a change from parasitic to productive life (Toynbee, 1934; Childe, 1952). In view of the commencement of desiccation in N.W. India right after the last glaciation, as the author has tried to show above, the possibility of such an influx without appreciable interval cannot be summarily rejected in the case of this region. It is true that "the food-producing revolution does not seem to have taken place in the deserts" as Butzer (1964: 436) has pointed out. But looking at the location of early food-producing settlements in the semi-desertic areas in the Middle East situated in the 8 to 24 inches rainfall zone one wonders whether this theory can be discarded altogether. The major part of N.W. Indian plains specially towards the south today receives almost the same amount of rainfall where the sparse vegetation had never grown beyond the limits of steppe. Neither proposing to validate the implication of this theory in connection with the problem of the origins of food production nor championing the arguments in favour of a standardised natural habitat as is seen in Western Asia because both face the threat of rejection when the new evidences for early food-production in S.E. Asia (Taiwan and Philippines) and North China become established, attention may be drawn to the situation of the arid plains of N.W. India with its oasis valleys close to the foothill areas which is somewhat similar to the northern part of the Fertile Crescent. If "from the very beginning, man could take up his abode on the levees or on the desert margins of the Near Eastern flood-plains" (Butzer, 1964: 463), there is no reason not to presume such events taking place on the plains of N.W. India. Being surrounded by a desiccated topography these valleys eventually must have attracted plant life and a few species of animals where man perforce had also to confine himself for a major part of his time. This close circuit of man, animal and vegetation, to our mind, holds the key to the solution of the problem of Late Quarternary lithic developments in N.W. India.

The absence of microliths in this region could have been one of the consequences arising out of this environmental confinement. Easy availability of game animals which were small sized herbivores within the limits of a small confined area must have provided no refuge for developing better skills in terms of new tool out-fit for hunting-chasing. In addition, there must have been for the time being plenty of other sources of diet like vegetable, fishes, etc., available in these oasis valleys to acquire which, little special skill or new types of implements

were necessary. Therefore, by and large at that time (till these natural food reserves were exhausted) the small flake-tools of Final Soan could effectively meet the immediate needs.

The second consequence of this confinement could have been that in the long run it gave rise to the necessary motivation for making efforts towards food-production. Exploiting the advantage arising out of the physical isolation of these valleys, man must have caused heavy damages to animal as well as to the vegetation by that impairing their natural growth and multiplication, the aftermath of which would have been felt in rapid dwindling of the natural food reserve. Adequate replenishment without human effort, as far as vegetation is concerned, could hardly come up naturally from the soil because of the peculiar morphology and composition of the *Khadar* and desiccation thereof as discussed above. Therefore, sooner than other places man in the region of N.W. India, felt the necessity to produce food, not much as consequences of accumulated techno-cultural knowledge but being goaded by peculiar local circumstances. This goes to explain the greater antiquity of the peasant village and Neolithic/Chalcolithic culture of this region vis-a-vis the Neolithic/Chalcolithic in other parts of India.

Due to rapidly deteriorating ecological condition the three alternatives suggested by W. Gordon East (1965) were probably adopted simultaneously by groups of men in N.W. India in different biotopes of the Early Holocene period. (1) Those who stayed where they were, had to modify their way of life in order to survive the hard conditions (*ibid.*: 49). It applies to the Sub-Himalayan *duns* where a polished stone celt culture succeeds the Final Soan. (2) Some "could emigrate in search of more familiar and congenial environments in the wake of the wild animals on which they depended for their food" (*ibid.*). This gave rise to a new way of living within the steppe-desert belt known as nomadism which means "cattle driving, or the movement of flocks and herds from place to place in search of scanty available pasture" (*ibid.*). Such pastures in the region of N.W. India being located at the fringe of the plains (where there were small patches of waterpools or lagoons of the marl-bed evidence) we find the stray remains of a microlithic culture with Neolithic bias at a few places in Sind, Baluchistan, and arid areas of Western Rajasthan.(3) The third alternative was thinking of a new kind of livelihood by means of cultivation and animal husbandry in which case man could explore the possibilities of the formerly neglected riverine lands (*ibid.*). We have

already discussed in detail the circumstances under which man, animal, and vegetation became localised in the *Khadar* areas which come under this alternative. The locations of early peasant villages in the flood-plains (Khadar) of small valleys situated in the foothill regions of Baluchistan, Sind, and N.W.F. Province indicate a preference for such places than the valleys of big rivers during the initial days of efforts for food-production. "Mixed farming for instance was practised very early in the valley of the Nile, the Euphrates and the Tigris yet the oldest sites where mixed farming, probably transhumance, can be affirmed are not situated near the banks of these great rivers, as has been believed previously, but rather on some of the adjacent plains and foothills" (Narr, 1956: 138). The veritable unhealthy swamps in the valleys of big rivers, like the Indus system, were probably a strong deterrant to human settlement till the beginning of the Protohistoric period as D.N. Wadia has rightly pointed out (Wadia, 1957).

Recent excavations of Sanghao Caves in N.W. Frontier Province of Pakistan throw interesting light on the problem of those isolated microlithic industries which are found on the plains bordering the foothills (Dani, 1964). Three periods of occupation of the cave contain a lithic industry which is mainly Levalloise-Mousterian in character with a few microlithic blades and cores appearing towards the end (Allchin, B & R., 1968). Although whether these microlithic can be typologically equated with those of the Upper Palaeolithic of West and Central Asia or with the Late Stone Age (Mesolithic) types of Peninsular India is a matter yet to be settled, there should be hardly any doubt that the Sanghao lithic complex contains in itself the evidence of an autochthonous growth of the microliths. These once invented could easily spread to certain areas on the plains nearby as tool out-fits of those nomads who chose to adopt the second alternative during the Late Quaternary desiccation as discussed above. But the very fact that the microlithic industries, despite this local origin did not greatly multiply in Punjab N.W.F. area further supports our point of view that the plains of the Punjab due to reasons of ecological peculiarities could provide little encouragement to Mesolithic way of life.

From quite a number of early peasant village sites bordering the north-western edge of the sub-continent stratigraphic evidence shows existence of a sort of mixed economy based on both semi-nomadic pastoralism and sedentary agriculture (Braidwood, 1961). Although

the continuance of the former even when man has learned to settle down may be explained as a matter of preferential group behaviour, the economic relevance of both the ways of life cannot be separately assessed at this rudimentary stage of cultural development when more often than not interraction of both was bound to take place where mutual adjustments were called for more as a matter of necessity than choice.

If viewed from this point most of the microlithic sites of Gujarat and Rajasthan with varying proportion of pottery and other allied traits of settled culture will no more pose problems. It could be that by about 5000 B.C. a new culture fully accustomed to sustain itself in arid circumstances had reached this area. This, the culture of the microlith using people, had its initial development in the western foothills and not in the local lithic industries (Palaeolithic) is suggested by the Sanghao evidence. As is natural in the arid areas, the culture was bound to be more pastoral than agricultural; rather nomadic at the initial stage. This is amply manifested through the preponderance of food-gathering type of microliths in Rajasthan area. But where the folks happened to strike suitable riverine lands quick techno-economic transformation towards food-production through cultivation (Neolithic) could be the logical outcome. This probably is the reason why in the region of N.W. India little distinction can be made between the Mesolithic and Early Neolithic. Here we have more evidence of quick diversification than of a slow transformation which could naturally appear as overlapping succession.

This Post-Pleistocene kaleidoscopic cultural pattern will appear less hypothetical if one carefully looks into the antecedents of the Hoabinhian, the Joman, and the early food-producing cultures in the Western Honan province of North China. Almost identical to our reconstruction these cultures in S.E. Asia and Northern China are independent developments in widely divergent ecological situations from local Upper Palaeolithic bases as active responses to the post-glacial environmental changes (Chang, 1970). Here is no Mesolithic transition.

CONCLUSION

The cultural growth in N.W. India during the Pleistocene has been traced through the various stages of the Soanian. Its distinctive features suggest that the contemporary conditions of the terrain had played a dominant role in giving shape to its basic character and later

pattern of progress. In this no one factor in the changing biotope can be considered primary.

With due regard to the local ecosystem and ethology it is probable that at the end of the Pleistocene dispersal of fauna had taken place causing thereby some movement of man. Three hypothetical techno-economic alternatives at this crucial point of cultural growth are suggested by the author. Primarily due to the absence of conditions for the growth of a Mesolithic culture a comparatively earlier beginning of food-producing economy can be visualised in this region. This, however, is not to suggest that N.W. India was the Garden of Edèn. Neither should it mean that food production had started in this region immediately at the end of the Pleistocene. The transition could have been through a stage when emphasis on hunting slowly shifted to vegetative planting of non-seed tropical tuber plants and incipient animal taming. Probably being too brief this stage left behind no durable evidence. Under these circumstances what could have been the course of human action from this time till late protohistoric period can be visualised in three phases of development.

Due to its peculiar geo-tectonic history and morpho-environmental isolation the Sub-Himalayan region could have emerged as an optimal zone where a symbiotic equilibrium between man and animal probably existed throughout the Pleistocene. During this period man did not live on the plains but was present in Thar region (Mohapatra, *et al.*, 1963).

First Phase: As consequences of changed environment during the Early Holocene man tried to expand the ecological range of those resources over which he had depended so long. Therefore, it became imperative to move out of the foothill *duns*. Descending on to the plains at the wake of post-glacial desiccation man could begin simultaneous exploitation of several different ecosystems. The equipment of those coming from the foothill *duns* of Himachal Pradesh consisted of small flake tools (Final Soan) and those coming from the Western foothills of Baluchistan and N.W.F. area were probably the users of microliths.

Bifurcation of population, adopting two different modes of living on the plains, i.e., pastoral nomadism for those who did not happen to strike congenial riverine lands and cultivation for those who did strike, seems to have taken place by about 5000 B.C. Those who were left behind in the *duns* developed the polished stone celt culture which is the only true Neolithic remain found in this region. Closely succeeding

the Final Soan (Palaeolithic) it symbolises the beginning of an effort towards incipient food production as far as the Sub-Himalayan zone is concerned (Mohapatra, 1974b).

Second Phase: Due to fast deteriorating ecology cultural innovations came to be accelerated. Food-producing areas gave rise to urban nucleus which expanded its girth in course of time to cover adjoining river valleys. Thus the foundation of the first civilization (Harappan) came to be laid originally at the north-western corner of the plains. Its expansion in fact was the second major enlargement of human settlement on the plains covering a much wider area than that during the first phase.

Third Phase: Further expansion of human settlement and exploitation of natural resources on the plains can be noticed during the early days of the Indo-Europeans (Aryans of the Rg Veda) in India. A critical appreciation of the culture and economy as gleaned from the Rg Veda and a comparison between the small ill-developed Early Grey-Ware sites of minor temporary village nature in this area and the larger well-diversified ones in the central Ganga-Yamuna doab do not suggest any great cultural consolidation of these people on the north-western plains. Due to progressive ecological deterioration, the old valley stations made arable by the Harappans through agro-based efforts could hardly hold a basically pastoral people for long. Across the Aravallis there was the promise of 'fresh fields and pastures new'.

The outline of cultural growth pattern thus drawn is no doubt hazy. Looking into the dimensions of the problem and the infant state of the research, the author's thesis can at best be regarded as a provocation to dialectic exercises.

"Whatever be the fate of my arguments, any one who collects and groups a mass of evidence, and makes an attempt to turn it to account which may lead to something better, has, I think, a claim to be exempt from any very harsh criticism of mistakes and omissions. As the Knight says in the beginning of his Tale:

I have, God wot, a largë feeld to ere;
And wayke ben the oxen in my plough.

Edward B. Tylor
Researches into the Early History of Mankind and the Development of Civilization. London. 1878.

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Index

Acheulian culture, 123
Adial Chauntra, 15
Aegyptopithecus, 7
Aiyengar, N.K.N., 2
Akhnoor, 76
Allahabad, 22
Allahabund, 47
Allchin, Bridget, 118, 119, 127
Alluvial deposits, 72-6, 82-4, 87
American Museum of Natural History, 2
Anantnag, 78, 79
Anchar Lake, 84
Andamans, 24
Antecedent rivers, 103-5
Aravalli hills, 119, 130
Archaen, 13
Aryan culture, 121-2, 130
Ashton, E.H., 8
Asia, South East, 24, 113, 125, 128
Assam, 24, 25, 41, 113
Awantipur, 78
Awasthi, N., 42
Awasthi, P., 82

Babeh river, 87
Badam, G.L., 71, 82
Badgam, 78, 79
Baghdad, 41
Bagor (Rajasthan), 47, 118
Bain Boulder Bed, 67, 72
Baker, W.E., 1
Balu-Goloa (Himachal Pradesh), 24
Baluchistan, 14, 49, 126, 127
Bandyopadhyay, N.N., 21, 23.
Banganga river, 74
Banerjee, D., 21, 22, 23, 25
Bangla Desh, 24
Baraia area (Kutch), 42
Baramula, 79
Barley, 49, 50
Basoli, 76
Baspa river, 87
Bawan, 83
Beas Valley, 74, 76, 110
Belon River, 21
Bengal, 24, 25, 113
Bhakra-Nangal area Environment, 23, 24
Bhandari, L.L., 21
Bhangar land, 114, 115
Bhatia, S.B., 21, 25, 69, 74, 75, 79, 80, 81, 84, 101, 102, 115
Bhatia, T.R., 71
Bhatt, D.K., 82
Bhed Khad (Himachal Pradesh) Environment, 23
Bhimbetka (Bhopal), 47
Bhopal, 22, 47
Bijbihara, 78, 79
Bilaspur, 68
Bombay, 22
Boru, 78
Bose, S.G., 74
Botapathri, 78
Boulder Coglomerate Formation, 14, 15, 26, 67, 68, 69, 72, 74, 79, 83, 109
Quaternary sediments, 71-2
Bovids, 14
Braidwood, R.J., 127
Bramapithecus, 2, 3
British Museum of Natural History, 11
Brown, B., 2
Buckland, W., 1
Budha Pushkar, 118, 119
Burma, 24, 25
Burzahon village, 84
Butzer, K.W., 125

Camelids, 14
Carnivores, 14
Cautley, P.T., 1
Cercopithecus, 1
Chakgajram village, 75
Chandigarh, 24, 68, 69, 75
Chandra, P.R., 78, 82

Chang, K., 129
Chaomukh, 15
Chapman, V.J., 41
Charophytes, 25
Chatterjee, S.P., 14
Chaudhri, R.S., 68
Chenab valley, 74, 76, 110
Childe, V. Gordon, 125
China
  Culture, 125, 128
  Pleistoscene deposits, 7
Chĩnji deposits, 12
Choe terraces, 72-6, 99, 100-2, 105, 106
Chopra, S.R.K., 1, 4, 5, 6, 7, 66, 75
Clark, J.D., 123
Clift, W., 1
Climate, 52-3
Colbert, E.H., 2, 10
Conroy, G.C., 11
Corruccini, Robert S., 7
Cotter, C.A., 73
Cultivation, 47-50, 119, 128
Cultural growth, 107-33
  Holocene, 124-8
  Phases, 129-30
  Pleistocene, 109-12, 122-4
  Vis-a-vis environment, 120-2
Cynometra, 24

Dagshai beds, 110
Dainelli, G., 78, 82, 85, 86, 111
Dal lake, 84
Darind, 78
Dayal, R., 21, 24
Dehadrai, P.V., 68, 72
Desai, R.N., 26, 77
De Terra, H., 1, 15, 26, 27, 74, 76, 78, 79, 81, 82, 84, 85, 86, 109, 111, 114
Dharamsala, 73
Dhauladhar Range, 73
Dhokpatham deposits, 6, 12, 79, 109
Didwana, 35, 37
  Pollen diagram, 39
Dipterocarpus, 24, 25
Djebel, 123
Drainage network, 102-3
Drummond, J.H.J., 123
Dryopithecine fossils, 2, 11-12
Dryopithecus, 2, 3, 4, 6, 11
Durand, H.M., 1

Earthquake, 1819 (Kutch), 47, 53
East, W. Gordon, 126
East Africa, 9
Egypt, 121
Environment, 20-65
Equipds, 14
Ettel, P.C., 7
Europe, 12
  Miocene deposits, 9

Falconer, H., 1
Farooqi, I.A., 26, 27
Fayum Oligocene, 7
Ferishta, 1
Fire, Knowledge of, 47
Fissistigma Wallichii, 24
Food production, 107, 119, 128
  Environment, 47-51, 54
Foote, Robert Bruce, 15
Forest clearance, 48
Fossil hominoids, 1-2
Frayer, D.W., 7
French Institute, Pondicherry, 37

Ganderbal, 79
Ganeshpur, 83
Ganga plains, 49, 50
Gansser, A., 73
Garhwal, 24
Gaussen, H., 37
Geddes, Arthur, 115
Geological Survey of India, 2, 3, 26
Geomorphological components, 98-100
Ghaggar river, 105, 120
Ghod river, 43
  Pollen analysis, 46
Ghosh, A.K., 21, 25, 42
Ghosh, S.S., 21, 25, 42
Gigantopithecus, 6, 7, 8, 11, 12
Gill, W.D., 71, 72, 109
Giraffids, 14
Glacial, 72-6, 82-4, 96
Goldwin-Austen, H.H., 81, 82

Gogajipathri, 82
Gordon, D.H., 113
Goswamy, S.K., 82
Grasses, 48, 50, 54
Greenfield, L.O., 11
Gregory, W.K., 2, 3
Grinlinton, Mr., 83
Groves, C.P., 7
Gujarat, 117, 119, 128
  Environment, 42-7, 53
Guler village, 74
Guleria, J.S., 42
Gulmarg, 77, 78
Gupta, H.P., 22
Gupta, V.J., 4, 15, 66, 110
Guzder, S., 22

Haigam pollen diagram, 29
Halstead, L.B., 70
Hamirpur, 68
Hangrang valley, 84
Har Raipur (Himachal Pradesh), 74
Harappa, 121, 130
Hardwar, 24
Hari Temple, Haritalyangar, 8
Haripur village, 74
Haritalyangar, 3, 4, 12
Hawkes, J., 84
Hazara, 49
Heim, A., 73
Hellman, M., 2, 3
High cup-shaped basins, 105
Himachal Pradesh, 22, 33, 53
  Pollen analysis, 62
Himachal Pradesh University, 87
Himalayas, 13, 49
Himalayas, North-West
  Environment, 22-34
  Quaternary sediments, 66-97
Holocene developments, 112-13
Hominidae, 10, 11
Hooijer, 10
Hoshiarpur, 68
Human origins
  Palaeontological evidence, 1-19
Hutchinson, C.E., 78

Inamgao, 21, 43
Indraloris, 1
Indus river, 110, 120
International Geological Congress (1948), 67
Islamabad, 83
Isolated molar, 4, 5-6

Jain, J.P., 86
Jaldhaka, 111
Jammu, 15, 68, 76
Jolly, C.J., 7, 11
Joshi, R.V., 74, 75, 83, 108

Kaldihwah (U.P.), 48
Kalibangam, 50, 121
Kalimatti
  Pollen stratigraphy, 32
Kallar, 15
Kamru, 87
Kangra, 68
  Nagri beds, 4
Kar, N.R., 14, 74
Karewa formation, 13, 14-15, 26, 27-8, 33, 34, 37, 66, 68, 77, 78
  Fossil fishes, 82
  Mossuses, 81-2
  Ostracodes, 80-1
  Plant fossils, 82
  Quaternary sediments, 76-82
  Taxa, 81
  Vertebrates, 82
Kargil Basin
  Quaternary sediments, 84-6
Kashmir, 13, 15, 22, 48, 49, 50, 54
  Environment, 26, 33, 34, 52-3
  Ostracode fauna, 84
  Pollen analysis, 29, 32, 61
  Quaternary sediments, 84-6
  River terraces, etc., 82-4
Kathmandu valley, 29, 59-60
  Pollen analysis, 29, 30-1
Kaul, S., 4, 5, 6
Khadar land, 114, 115, 126, 127
Khan, E., 67, 71, 73, 74, 98, 101
Khanna, A.K., 21, 24
Kharkwal, A.D., 68
Khokhra (Himachal Pradesh), 24
Khosla, S.C., 69, 115

Khrew, 84
Khundian village, 24
Kiaser Tao, 86
Kinnaur
  Quaternary sediments, 87
Kishanpura village, 74
Koldihwah, 49
Krynine, P.D., 12
Kumaun, 14, 24, 49, 63
  Naukutchiyatan pollen diagram, 29
Kuppa, 87
Kurungus, 83
Kutch
  Environment, 42-7

Lacustrine deposits, 72-6
Ladakh
  Quaternary sediments, 84-6
Lahiri, H.M., 110, 111
Lakes, 115, 116
Lakhanpal, R.N., 21, 24, 42
Lakhanpur, 76
Lal, B.B., 50, 74
Lamayum, 84
Langhnaj, 118
Larix, 25
Latapora, 78
Leakey, L.S.B., 11
Learmonth, A.T.A., 115, 120
Lesser Himalayan Zone
  Quaternary sediments, 69-76
  River terraces, etc., 72-6
Levant, 121
Lewis, G.E., 1, 2, 3, 10
Liddarmarg, 82
Lidder valley, 79, 83, 84
Limnopithecus, 9
Litho zones, 26
Lolab valley, 79
Lothal (Gujarat), 121
Lotsum, 85
Lower Pleistocene, 15
Lunkaransar, 35, 37, 41
  Pollen diagram, 38
Lydekker, R., 1, 2, 4, 76, 79

Macacus, 1
Madras, 15
Mahabale, T.S., 42
Mahajan, D.R., 42
Maharashtra
  Environment, 42-7
Malakpur, 15
Mallet, F.R., 73
Malvan (Gujarat), 22, 43, 47
  Pollen diagram, 45
Man-plant relationship, 47-51
Mandibular fragment, 4, 5
Man's habitat, 98-106
Mansbal lake, 84
Markanda valley, 74, 75
Mastanpura, 110
Mathur, A.K., 21, 25, 69, 74, 75, 101, 112
Mathur, Kewal, 42
Mathur, L.P., 70
Mathur, Y.K., 42
Medhcott, H.B., 73
Megafossils, 20, 21, 24
Mehta, K.P., 82
Mesopotamia, 121
Mesuruer, 15
Microfossils, 20, 21
Middle East, 125
Middlemiss, C.S., 14, 73, 81, 82
Milletia, 24
Millets, 50
Mio-Pliocene, 12, 16
Mirgund, 78
Mirzapur, 22
Misra, V.N., 118
Moginand, 70
Mohand (Himachal Pradesh), 23, 24
Mohenjodaro, 121
Mohapatra, G.C., 74, 76, 83, 103, 104, 105, 107, 110, 113, 122, 123, 124, 129, 130
Morris, T.O., 72
Mossin, J.J., 104
Mugharet-es-Skuhl, 123
Mukerji, A.B., 73, 75, 98, 123
Mula Dam (Maharashtra), 42
Mulbekh, 85-6

Naera area (Kutch), 42
Nagam, 78

Nagin lake, 84
Nagla terrace, 75
Nagri deposits, 12
Nagrota, 76
Nahans deposits, 12
Naik, P.K.K., 82
Nakata, T., 73, 74, 75
Nalagarh, 110
Nalsarovar, 22, 42-3, 44, 53
Nanda, A.C., 70
Nandi, Bharati, 21, 23, 70
Narr, Carl J., 127
Naugam village, 80
Naukutchyatal pollen diagram, 29, 32
Nepal, 14, 15, 22
Nepal diagrams, 29-32
Nichahom, 78
Nilgiris, 42
Ningalnala, 82
North America, 13
North West Frontier Province, 127

Orissa, 113

Pahlgam, 83
Pakistan
  Potwar region, 12
Papio, 1
Pampur, 78, 79, 84
Pandey, B.K., 68
Pandey, J., 4
Parkash, B., 72
Pascoe, E.H., 111, 115, 117
Pashkyum, 85
Paterson, T.T., 1, 15, 26, 27, 74, 78, 79, 81, 82, 84, 109, 110, 123
Pattan, 78
Pilbeam, D.R., 2, 3, 4, 7, 10, 11
Pilgrim, G.E., 1, 67, 72, 79
Piliopithecus, 8-10, 12, 14
Pinjore formations, 14, 24, 25, 26, 67, 68, 109, 110
  Fauna, 70-1
  Quaternary sediments, 69-71
Pinus, 25
Pir Panjal, 29, 32, 34, 52, 76, 79, 83, 111
Plains, 114-17
Pleistocene, 13-14, 15, 16, 26
Pokharpura formation, 26
Poonch, 79
Porter, W.C., 84
Post-Pleistocene archaelogical hiatus, 117-20
Potwar, 15, 109
Prakash, U., 21
Prasad, B., 81
Prasad, K.N., 1, 3, 4, 10, 11, 68
Prava river basin, 42
Prince of Wales College Museum, Jammu, 3
Proboscidians, 14, 15
Punjab, 15
Purekar, P.N., 82
Puri, G.S., 26, 82, 117
Pushkar lake, 35

Quaternary sediments, 66-97

Rajasthan, 13, 16, 22, 47, 50, 117-18, 119, 126, 128
Rajasthan desert
  Environment, 34-42
Raju, A.T., 68, 72
Ramanagar (J & K), 12
Ramapithecus, 2, 3, 4, 6, 10-11, 12, 16
Randhawa, M.S., 21
Rao, A.R., 82
Ravi valley, 74, 76, 110
Rawat, M.S., 21
Red Crag (East Angolia), 67
Reptiles, 15
Rice, 49
Rikes, R.L., 120
Rimbiara valley, 26
River terraces, 72-6, 82-4, 95, 103-5, 110
Robert, R.D., 26
Robinson, J.T., 7
Rodents, 14
Ropar, 121
Ror village, 74
Roy, D.K., 78
Rupshu (Ladakh)
  Quaternary sediments, 86
Rythen, 78

Sah, S.C.D., 21, 24
Sahni, B., 11, 21, 77
Sahni, M.R., 67, 70, 71, 73, 74, 98, 101
Sahni Institute, 35
Saluikha, S.K., 21, 22
Sambhar salt lake, 35, 37, 41
  Pollen diagram, 40
Sanghao cave, 113, 127
Sangla, 87
Sankalia, H.D., 15, 83, 108
Sarai Nahar Rai (UP), 47
Saraswati valley, 120, 121
Saroj, H.M., 76, 110
Sastri, V.V., 4
Sastry, M.V.A., 14
Sauer, Carol O., 118
Saxena, A.N., 26, 35
Saxena, M.N., 108, 110
Sen, D., 73, 74
Sharma, Chhaya, 22, 43
Sharma, R.S., 122
Sharma, S.P., 21, 22, 25, 69
Sharma, V.K., 73, 74
Shergol, 85
Shyam, M., 98
Simons, E.L., 2, 3, 4, 6, 7, 10, 11
Sind, 126, 127
Sind valley, 79, 83, 84
Sindri Fort, 47
Singh, B., 75
Singh, D., 79, 80, 84
Singh, Gurdip, 22, 26, 29, 32, 34, 35, 36, 38, 39, 40, 41, 47, 118, 119, 120, 121
Singh, H.P., 21, 22, 23, 25
Sirsa valley, 74
Śivalik Hills, 66, 68-9
  Environment, 22-5
  Location, 98
  Man's habitat, 98-106
  Primate palaeontology, 1-19
  Quaternary sediments, 69-72
Śivalik Orogeny, 109
Sivapithecus, 2, 3, 4
Soan culture, 15, 110, 111, 112-13, 122-3, 128, 130
Sombur, 79, 84
Spate, O.H.K., 115, 120
Spiti valley
  Quaternary sediments, 86
Srinagar, 78, 84, 111
Steudel, K., 7
Stone Age artefacts, 74
Stone Age tools, 15, 16
Sub-Himalayan terrain, 114
Suids, 14
Suneja, I.J., 66, 82
Suru river, 84, 85
Sutlej valley, 110, 115-16
  Alluvial deposits, 87
  Quaternary sediments, 87

Tatrot Formation, 14, 25, 67, 69
Tattersall, I., 1, 11, 12
Tawi river, 76, 110
Taylor, 15
Tethys Himalaya
  Quaternary sediments, 76-87
Tewari, B.S., 21, 25, 93
Thar, 115, 120, 129
Theobald, W., 73
Tilwara excavations, 118
Tosmaidan pollen diagram, 29, 32
Toynbee, A.J., 125
Trinkler, E., 85
Tripathi, C., 78, 82
Tso Morar valley, 86
Tylor, Edward B., 130

Udhampur, 76
Ungulates, 15
Urban culture, 118-19, 121

Varma, C.P., 21
Venkatachala, B.S., 21, 23
Verinag, 84
Verma, B.C., 1, 70
Villafranchian, 67
Vishnu-Mittre, 20, 21, 22, 26, 29, 32, 33, 35, 42, 43, 47, 48, 50, 52, 78, 79, 114, 118-19, 121
Von Meyer, H., 1

Wadia, D.N., 2, 13, 14, 67, 78, 79, 82, 117, 127

Wakka valley, 85
Webb, 1
Weichselian pollen sequences, 22, 29
Wheat, 49, 50
Wheeler, Mortimer, 107
Wheeler, R.E.M., 113
Willkomm, H., 29
Wisemann, Von Herman, 111
Wodehouse, R.P., 82
Wolpoff, Milford H., 11
Woo, J.K., 7

Yale-Cambridge expedition (1935), 2
Yale-North India expedition (1931-32), 2
Yamuna river, 115-16
Yusmarg, 78

Zangam plateau, 82
Zeuner, F.E., 111, 118
Zuckerman, S., 8